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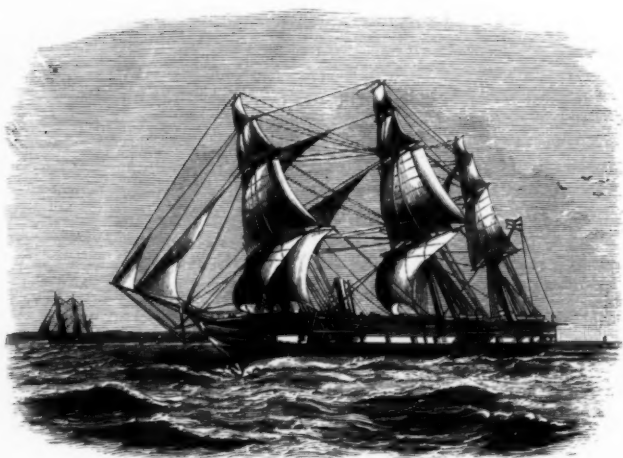
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H.M.S. "CHALLENGER."

1872-1895.



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NATURAL SCIENCE:

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NO. 41. VOL. VII. JULY, 1895.

NOTES AND COMMENTS.

FINIS CORONAT OPUS.

THE publication of the *Report* of the "Challenger" Expedition has been brought to a close with the issue of the two volumes reviewed in our May number. It is our English custom to accept our great deeds with equanimity, as no more than fitting, or even as inevitable. There is a merit in this peculiar form of pride, and yet it has its dangers. It is to be feared that Englishmen do not really appreciate this undertaking at its full value; they count the cost, but fail to see the profit. This is natural, for such explorations immediately appeal to only a limited class, however much their ultimate results may benefit the world at large. Moreover, in the present instance, the mere magnitude and duration of the performance remove it from the grasp of the individual; there are few who can form an adequate conception of all the results. We have, therefore, attempted to play the part of the philosophic historian, to show the "Challenger" Expedition in its true perspective, and to estimate the worth of its additions to science. We could not have made this attempt without the cordial assistance of the numerous eminent authorities, many of them the actual writers in the "Challenger" *Report*, who have so generously answered our call. Our heartiest thanks are here offered to them, and to many others whose names do not appear on our title page, but who have given help in revising, suggestions, and good-wishes. To our foreign friends we are specially grateful; it was only fitting that they, without whose help the "Challenger" collections could hardly yet have been worked through, should have the opportunity of personally appearing in this summary. We regret that obstacles of time and space have prevented yet more of them from contributing. Warm thanks are also due to the "Challenger" Office in Edinburgh for the loan of the wood-cuts that illustrate the present number.

The question proposed to our contributors was—How has the "Challenger" Expedition advanced science? And each was requested to answer this question for his special field of knowledge. One has answered the question on one line, another on another; the limits of space made it impossible to discuss all aspects of the subject, and by leaving the mode of treatment to the discretion of the different writers, greater variety has been obtained. In zoology, for instance, this writer has dealt with the facts of distribution, that one has plunged into pure morphology, yet another has detailed that increase in knowledge of genera and species upon which the broader results are based. But our readers must remember that there was advance in every direction, and that what is implied by any one of these writers is often as much and as valuable as that which is explicitly stated. There is one section which, though outside our usual scope, we are specially glad to publish, that, namely, written by the navigating officer of H.M.S. "Challenger," now Assistant-Hydrographer to the Admiralty, and discussing the results to hydrography and navigation. Here, at least, is something of which the man in the street can see the value; every addition to our knowledge of the ocean currents, the ocean floor, the ocean winds, is an addition to the safety of the sailor, to the ease and speed with which voyages may be accomplished, and to the intercourse of the nations. Every Briton is proud of Britannia's Navy; but let us remember that it is something more than our empire's fighting machine, that it has been in the past, and will be still more in the future, the servant of the world, and a most potent agent in the peaceful union and advance of all its peoples.

SOME LESSONS FROM THE "CHALLENGER."

IN every great undertaking of this kind, where so many interests are involved, and where so much depends on the accuracy and co-ordination of small details, there must necessarily be some failures, and this experience of failure is as valuable to future undertakings as is the experience of success. Some of our contributors have mentioned these weak points, in the hope that they will be guarded against by any forthcoming expedition. Already the lesson of the "Challenger" has led to great improvement in the methods of capture of oceanic animals. It was often impossible to tell from the old method at what depth an animal found in the net really lived; so that animals of markedly pelagic organisation were brought home labelled "2,000 fathoms" or thereabouts. By the introduction of nets that can be opened and closed while below the surface, these errors are now avoided. Again, the enormous advance that has been made in the technique of preparing organisms for microscopic examination cannot fail to render the results of a future exploration even more valuable than those of the "Challenger." Much histological work proved

impossible owing to the somewhat crude method of preservation in force twenty-three years ago, and the length of time that many of the objects had to remain in unchanged spirit. Many of the reporters, too, had to do their work without the assistance of the elaborate appliances now found in every laboratory. Other suggestions for future explorations are given in the *Narrative*. There is, however, one other point that should not be overlooked. Those who originally planned the form that the "Challenger" *Report* should take can hardly have imagined the length to which it would run. Its size and cost are not such as to predispose "My Lords" to sanction future expenditure on a similar publication. No one questions that the results are worthy of the best paper, printing, and illustrations; but the promoters of any contemplated work of like nature would be wise in their generation if they were to adopt a less expensive scale and a *format* more convenient to the desk and book-shelf of the ordinary student.

BATHYBIUS.

ONE of the earliest and most disappointing of the "Challenger" discoveries was that of the true nature of the "Bathybius." Professor Huxley, while examining deep-water dredgings, taken by Dayman, and preserved in strong spirit, found abundant traces of a grey gelatinous mass, resembling protoplasm in appearance, and containing embedded in it numerous minute structures which he called Cocoliths and Rhabdoliths. These were the early days of protoplasm, and Huxley, with a natural enthusiasm, suggested that what he found might be the remains of a primitive living slime, an amorphous mass stretching along the ocean bottom, as a continuous and almost unorganised beginning of life. As we all know now, the "Challenger" naturalists found that Bathybius was a flocculent precipitate formed when strong spirit was poured into sea-water, and that it was not and had not been alive. There was fierce exultation among the enemies of science, who were as delighted as if the whole theory of evolution had tumbled down with the collapse of Bathybius.

We need hardly point out that the reality or non-reality of Bathybius had no greater importance than that of any isolated zoological fact. So far as naked masses of protoplasm go, the plasmodia of many of the slime fungi, the naked masses of protoplasm that creep over tan-bark and decaying organic matter have a theoretical interest as great as a real Bathybius would have had. Moreover, it is at least probable that some Bathybius-like creatures do live on the floors of the oceans. The "Challenger" results have shown that vegetable life does not occur there, that bacteria (at least the bacteria of putrefaction) are absent. Theoretical considerations make it probable that simple organisms devoid of chlorophyll are more primitive than organisms with chlorophyll. It would surprise no zoologist were there brought up from the multitude of

protozoa living at the bottom of the seas, naked amoeboid creatures, devoid of chlorophyll, living on crumbs and fragments of organic matter, and at times cohering into plasmodia large or small; and such creatures would correspond nearly enough to Huxley's idea of Bathybius.

H. N. MOSELEY.

No reader of our article on the "Challenger" Expedition will fail to observe how large and important a share of the work was done by the late Professor Moseley. In that province of natural science which is regarded as specially his own, namely, the Morphology of the Invertebrata, his influence was prominent. Apart from his special report on some of the Alcyonaria and Madreporaria, we find some of the most important discoveries in many groups due to him: the true nature of *Peripatus*, and of the strange worm *Pelagonemertes*, the new Tunicate *Octacnemus*, the phosphorescent organs of deep-sea fish; these and many others will always be associated with his name.

But Moseley recognised that, while the deep-sea was not likely to change its character for many a day, the customs of savages and the flora of oceanic islands alike were disappearing or changing. He chose wisely and deliberately to lose no opportunity of observing these decaying aspects of life. The botanical work he did is fully referred to by Mr. Baron Clarke; to what Professor Haddon says of his anthropological labours we may add a few words.

Both in lectures and in private conversation, Moseley used to say that the "Challenger" Expedition saw nearly the last of the unsophisticated savage. The advent of missionaries and the spread of commerce, however important they may be from other standards, are wholly lamentable from the point of view of anthropology. Moseley devoted a large part of his time ashore to the investigation of the manners and customs of the natives. He brought back an anthropological collection of the greatest interest and importance, part of which is in the museum at Oxford, and part of which has been distributed to various private and public institutions. But the knowledge of primitive customs he had acquired is for the most part lost. He was able to assist in the arrangement of the Pitt Rivers collection, which was put under his control by the donor, and so far a certain amount of his information was not lost. But it was a hope of many of his intimates, a hope frustrated by his death, that one day he would be able to write a volume on the habits and customs of savages.

IRISH SCIENTIFIC WORTHIES.

WE deeply regret to learn of the premature death of the Director of the Science and Art Museum at Dublin, Professor Valentine Ball.

A full notice of him must be deferred to our next number. One of his recent acts was to send the following letter to the *Irish Naturalist* :—

“For some time I have had it in contemplation to exhibit in a suitable part of the Museum a collection of portraits of persons identified with the progress of science in Ireland. Quite recently a number of portraits having become available for this purpose, and others, as the result of special correspondence, having been presented or promised, the time is now close at hand when the collection can be placed on view. I therefore desire to make known through the pages of the *Irish Naturalist*, that contributions and loans to this collection of portraits of eminent and acknowledged men of science belonging to the above denomination will be gratefully accepted. Circumstances have rendered it desirable that no restriction whatever should be put upon the style or nature of the portraits so contributed, no funds being available for securing uniformity. Hence we have decided to accept oil paintings, lithographs, etchings, or photographs, and to exhibit them as received, save that suitable frames will be supplied when needed. Portraits of mathematicians, astronomers, physicists, meteorologists, geologists, botanists, zoologists, antiquarians, and numismatists will be arranged in separate groups. In the cases of those who are deceased, short biographical notices will be attached to the portraits.”

We trust that this application will have the desired effect, and at the same time we suggest to those who will now carry it out as a memorial of their departed chief, that they might include autograph letters or manuscripts, as such are found useful in the identification of labels and other memoranda associated with specimens.

WEIGHTS AND MEASURES.

THE American Metrological Society has the praiseworthy object of advocating a rational system of weights and measures. To that Society as well as to our readers, we commend a treatise upon measures, recently published in London by Mr. Wordsworth Donisthorpe. In that he traces the past history of our existing standards and advocates a new system based upon the metric scale, by which, of course, the measures of length, surface, and volume would be correlated. Incidentally in his book he mentions some ingenious comparisons that may be found useful by our readers. All of us who use the metric system in scientific work, unless we have a very extensive habit of measuring, find it more or less difficult to realise actual dimensions when the metric names are applied to them. We all know what an inch is; how many of us could draw on paper a line of a millimetre or of a decimetre?

The millimetre, Mr. Donisthorpe says, is the length of the letters a. c. e. m., etc., in nonpareil type. The centimetre is a trifle less than the diameter of the little red wafers used by lawyers as seals opposite the names of the signatures upon a deed. The decimetre is within a sixteenth of an inch of the hand used in measuring horses; that is to say it is nearly four inches, the width of an average man's

hand. The cubic centimetre, the French millilitre, is about the size of French dice, which are a shade smaller than English dice. The litre is nearly a cube of four inches. It is about a pint and three-quarters, which Mr. Donisthorpe says is what we think of as a long drink.

THE DISTRIBUTION OF SCALE-INSECTS.

A RECENT note by Professor T. D. A. Cockerell (*Proc. U.S. Nat. Mus.*, vol. xvii., pp. 615-625) gives a summary of the numbers of genera and species of scale-insects (Coccidæ) known from various parts of the world. It appears that our ignorance of these creatures is as yet very great. A few areas have been well marked. Principally through the labours of Mr. Maskell, 108 species are recorded from Australia, and seventy-seven from New Zealand. Professor Cockerell thinks that the Coccidæ of the latter islands are better known than those of any European country. The recorded Palæarctic coccid fauna is believed to number about 200 species, while the Nearctic list numbers 127, the development of economic entomology in North America naturally accounting for attention to such a destructive family there. In our own country the group is being investigated by Messrs. J. W. Douglas and R. Newstead. Mr. Cockerell himself has paid much attention to scale-insects in the West Indies, whence come most of the 124 recorded Neotropical species, Brazil contributing some half-dozen to the total. From the entire Ethiopian and Oriental regions together fewer insects of the family are known than from the island of Jamaica. We see from this summary what an immense field for research lies open to naturalists who will pay attention to these minute insects. The sedentary habits of the females render inquiry into their distribution and means of dispersal of special interest, while no branch of zoology is more important to the gardener and the fruit grower.

IRISH FRESHWATER SPONGES.

IN a recent number of the *Irish Naturalist* (vol. iv., pp. 122-131) Dr. R. Hanitsch enumerates six species of Spongillidæ from Ireland, the British fauna containing but four species. Three of these occur in Ireland, the other three sponges, all from the west coast of the latter country, being also North American species. Dr. Hanitsch would not solve this interesting distributional problem by supposing a former extension of the sponges over the whole northern hemisphere; he believes that their gemmules could readily have been carried across the Atlantic by winds, ocean currents, or birds. In some remarks on the European distribution of the Spongillidæ, Dr. Hanitsch notices their extreme rarity in Southern Europe. Only one species is known from the Iberian peninsula (N. Portugal), two from the Italian, while none at all have been found in the Balkan.

The Scientific Results of the "Challenger" Expedition.

INTRODUCTION.

IT is nearly twenty-three years since I went down to Portsmouth to bid "good-bye" to my dear old college friend, Moseley, when the "Challenger" steamed out of Portsmouth Harbour on her expedition for the investigation of the biological, chemical, and physical conditions of the great oceans of the world. The final volume recording the results of that memorable expedition has now been issued, and we may attempt to answer the question as to whether it was "well done"; whether the results have been worth the expenditure of public money; and whether the record of those results has been satisfactorily set forth without undue delay, and yet with necessary accuracy and fulness. There is unanimous testimony in the affirmative. Never did an expedition cost so little and produce such momentous results for human knowledge.¹ Over and above the normal expenditure involved in putting the ship in commission—an expenditure which is not to be reckoned to the special purpose of the expedition, since it would have been incurred in the usual course of activity of her Majesty's navy—there was the cost of some special fittings, and of apparatus for dredging and sounding, and of the means for preserving and transporting specimens. Besides this, there were the salaries of Wyville Thomson and his assistants—Moseley, John Murray, Buchanan and Willemoes-Suhm. The expenditure on the preparation and publication of the *Report* has been relatively greater; but the authorities of the Treasury may rest assured that the whole scientific

¹ The estimated cost of the "Challenger" Expedition while afloat was £30,000 per annum, but there is no means of knowing how much was actually spent on the expedition. Probably £90,000 is above the mark for the total naval expenditure. The "Challenger" was a man-of-war, in which nearly all the usual drill was carried on throughout the voyage, and the pay of the officers and blue-jackets, the most costly part of the expedition, cannot be regarded as an extra cost to the nation. The salaries of the civilian scientific staff while afloat amounted to £2,200 per annum. The total extra charge to the country for carrying out the scientific work on board the "Challenger" during the whole cruise may be put down at about £20,000.

The expenditure in connection with the care, examination, distribution, and description of the collections after the return of the expedition, together with the necessary researches and investigations and the preparation of the fifty volumes of the *Report* for the Press, was about £48,000—that is to say, the expenditure from public moneys; but many of the contributors have spent some of their own funds as well as their time in connection with their contributions to the publications.

world sets the very highest value on these volumes, and that, had it suited the dignity of an Imperial Government to treat the work on a commercial basis, instead of liberally presenting copies of it to scientific institutions throughout the world, the publication could have been made completely to pay its own expenses by sales.

Sir Wyville Thomson, on the return of the Expedition in 1876, was appointed to superintend the publication of the results, for which an annual sum was voted by Parliament. It was arranged that the Stationery Office should publish the work, and that all the collections, after they had been reported on, should be deposited in the Natural History Branch of the British Museum. Sir Wyville made some of the arrangements as to the distribution of the collections to experts for report, and decided upon the general form and style of the volumes to be issued; but his health broke down soon after his return home, and in 1882 he died. Suhm had died on the voyage, and eight years later another of the naturalists, Moseley, was taken from us, so that only John Murray and Buchanan now remain of the civilian staff of the "Challenger" Expedition.

On the death of Sir Wyville Thomson, Mr. John Murray was appointed to take his place as director of the collections and editor of the *Report*. It is not too much to say that it was a rare good fortune for science, and for the reputation of the "Challenger" Expedition, that a man who has proved to be so peculiarly fitted for the work which had to be done was at hand. The feat that Mr. John Murray (now "doctor" of many universities) has performed is remarkable on the mere face of it. He has, with the aid of a well-chosen staff, sorted and sent out to specialists in all parts of the world the treasures brought home by the "Challenger"; he has obtained from those specialists, whose zeal and promptitude is worthy of grateful recognition, richly illustrated reports of the highest value; and he has seen these through the press and issued them, together with a general *Narrative* and a *Summary* of the results, in fifty thick quarto volumes. The collections have been returned and safely deposited in the British Museum. To have obtained such a result within twenty years after the return of the expedition is evidence of unflagging energy, industry, and tact on the part of the director and editor. But this is not all; for Dr. John Murray has throughout these twenty years kept his mind bent on the great general problems to the solution of which all this work tends. He has himself, in conjunction with Professor Rénard, written one of the most important and original of the reports, that on Deep-Sea Deposits—and now has crowned the period of his labours with a marvellous index-summary of results preceded by the best historical account of the rise and progress of the science of Oceanography which exists, and followed by an extremely important essay containing far-reaching generalisations relative to the history of the earth's surface of land and water, entitled "General Remarks on the Distribution of Marine Organisms."

In the preparation of the "Challenger" *Report*, Dr. John Murray rightly made no distinction of nationality when selecting expert naturalists to do the work. When a British subject was the best man to deal with a given group, and was ready to undertake the work and put it through in a reasonable time, he was gladly welcomed by Dr. Murray; when a German, Belgian, Dutch, Scandinavian, or American naturalist seemed to be the fittest person to report on a group, he was enlisted. Thus the volumes contain some of the best work of the most distinguished naturalists of all countries. But there was enough material to occupy many men for many years in study, and not the least important service rendered by the editor has been in bringing forward young zoologists who have won their spurs under his auspices and fully justified his selection. Among such may be mentioned Messrs. S. O. Ridley and Dendy, who took up certain groups of sponges; Mr. Quelch, who dealt with reef-corals; Dr. Pelseneer, who had some of the most interesting mollusca intrusted to him; and Mr. Hoyle, who made himself an authority on the Cephalopoda. It is needless to say that the man who has thus "driven" the "Challenger" team to the successful close of its journey is, though energetic and determined, no ordinary taskmaster. He has gained the esteem, friendship—I may say the affection—of all who have worked with him, whether reverend professors, such as Renard, Haeckel, and Agassiz, or young men fresh from college who have been his assistants.

The actual results, their amount and importance, will be reported on by others in these pages. But I may be allowed to say what is the bare truth, and that is, that the "Challenger" volumes form a library of zoological literature of the highest kind of excellence, such as has never before been issued in one series, under one editorship, and in so brief a space of time. Our knowledge of the sponges absolutely dates from the great volumes here devoted to this difficult and multiform group. The same is true of the deep-sea fishes and of the crinoids and holothurians. The systematist has to refer first of all to the "Challenger" volume for knowledge of the Pycnogonida, and for complete revision of the various groups of Echinoderma, Crustacea, Hydrozoa, and corals. Nor must we forget the important contributions to botanical science, or the great advances made in our knowledge of the ocean floor and ocean physics, as well as the light thus thrown on some of the larger problems of geology.

Britons—I hardly like, since John Murray is a Scotsman, to say Englishmen, though that term really includes as much and perhaps more than the former—may fairly be proud of the whole conception, execution, and carrying through of the "Challenger" Expedition and its results. It was that fine old soldier of Natural Science, Dr. W. B. Carpenter, who thought out and proposed the expedition—all honour to him!—but honour also to our oft-abused representative Government and Legislature, which cordially voted the supplies for the Expedition

when the Royal Society had endorsed Dr. Carpenter's suggestion. And, finally, congratulations to Dr. John Murray—and to all who have helped him—on the completion of his task, and on the honorary degrees showered on him by universities, and especially on the kindly and generous presentation to him, by the French Academy of Sciences, of the distinguished "Prix Cuvier."

The brilliant success of the "Challenger" Expedition and its *Report*, clearly point to the reasonableness of forthwith organising a similar enterprise by the aid of one of her Majesty's ships, for the purpose of filling up gaps and following out lines of inquiry which are patent to oceanographers and naturalists as the result of the consideration of the "Challenger's" work, and of that of other smaller but important expeditions which have followed it. There are now a large number of definite problems of the kind to which an immediate solution could be thus given. But, perhaps, the most interesting enterprise to British naturalists would be a biological and physical survey of the mud-line (of Murray) around the British Islands.

E. RAY LANKESTER.

I.—HYDROGRAPHY AND NAVIGATION.

THE combination of civilians with naval officers in the "Challenger" Expedition was most successful. Owing to the vessel being of a suitable size, each civilian not only had a cabin, but a work-room to himself; whilst the naval staff were also well accommodated. This enabled each member to work uninterruptedly at his own speciality, and to compare notes with the others in the smoking circle daily after dinner, a function always well attended, and one where the events and work of the day were freely and amicably discussed. To say that the civilians cheerfully endured the being cribbed, cabined, and confined to a movable prison with a chance of being drowned, hardly does justice to the alacrity they always exhibited, or to the constant interest they took in their work; whilst to the naval staff the close intercourse with men not brought up to a sea-life from a tender age, but educated in an entirely different school of thought, in the universities, had a charm which served to make the long voyages anything but tedious. That all were animated with the idea that it was their business to make the Expedition a success, is proved, not only by the evidence of the late Sir Wyville Thomson, in his letters to the Hydrographer of the Admiralty, but by the general results obtained, which are freely acknowledged to be worthy of the nation which equipped, and the members who accompanied, the Expedition.

The principal results of the "Challenger" Expedition from a naval point of view are:—

1. The proof that the variation of the compass can be determined as accurately in a ship, as on shore, if the ship is magnetically suitable.

2. The delineation for the first time of the contour lines of the great ocean basins.

3. The determination of oceanic temperatures, which subsequent observation has shown to be constant below the depth of 100 fathoms.

4. The proof of a constant bottom temperature over large areas in the ocean; found to be due to such areas being separated by submarine ridges from each other, and from the cold water of the polar basins.

5. The determination of the exact position of many islands and dangers, of which the longitude, especially, had been previously very uncertain.

6. The charting, as accurately as time permitted, of the various unsurveyed parts of the world sighted, or touched at, during the voyage.

7. The determination of the ocean currents both on the surface and at various depths.

1. With respect to the accurate determination of the variation of the magnetic needle on board ship, it is necessary to point out that before 1872 observations for variation taken by a vessel between any two ports were generally dependent for correction (for the direction of ship's head at the moment of observation) on the deviations obtained at these ports at the beginning and end of each voyage, corrected, of course, for the varying force of the magnetical elements. The usual method of obtaining a table of deviations, *i.e.*, of the errors of the compass due to local attraction of the ship itself, being to land one compass, and take reciprocal bearings on shore and on board, as the vessel was swung round laboriously by anchors and hawsers, with her head directed to each point of the compass in succession; in some cases, however, this had been done by bearings of the sun or of a distant object. It is evident that the correctness of the result, and of the variation curves, would be entirely dependent on there being no magnetic disturbance on the land.

Shortly after the "Challenger" left England a statement was made that the Admiralty chart of variations was considerably in error in the neighbourhood of the Bermudas, and instructions were given that this statement was to be investigated. On the arrival of the expedition at Bermuda observations were taken on shore, with the result that the needle in different parts of the island showed an extreme difference of 6° in the variation, *viz.*, from 4° W. to 10° W. —a somewhat surprising result in a group of islands of coral formation. The difficulty then was to find what the true error of the needle was, and the following plan was adopted:—

It is shown by the late Archibald Smith in the "Admiralty Manual for Compasses" that if a table of deviations, or local errors in a ship, be obtained by swinging the ship on a number of equidistant points, if the resulting easterly deviations be called + and the

westerly — , and that if the total of the easterly and westerly deviations be taken one from the other and the result divided by the total number of observations, this will give the constant error of the compass on each point. This co-efficient is named A. In a ship where the compass is placed exactly in the fore-and-aft line, and where the iron is evenly distributed, there will be no A. This was found to be practically the case in the "Challenger." By swinging the ship outside Bermuda by azimuths of the sun the total error of the compass, *i.e.*, variation + deviation, was obtained on each point. Taking the algebraical mean of all the observations, the constant error on each point is determined. This error is the variation + the A. In a ship, such as the "Challenger," with practically no A, the result is the variation.

This swinging in deep water proved so satisfactory that the system was adopted at many stations throughout the voyage, thus not only furnishing base-stations, independently of the land, for correcting the observations made between the base-stations, but also serving to ascertain whether there was any magnetic attraction on shore. Since the "Challenger's" voyage all vessels instructed to obtain magnetic observations have been ordered to adopt the system introduced by the Expedition at Bermuda.

2. Although, before the "Challenger" started, many ocean soundings had been obtained, especially in the North Atlantic between England and America, and in the Mediterranean, along the routes chosen for submarine cables, most of the earlier soundings were of somewhat doubtful value, as the means at the disposal of the first investigators were insufficient, and the method of obtaining accurate depths, when the soundings exceeded 2,000 fathoms, could only be ascertained after much experience. Depths of 7,000 to 10,000 fathoms were asserted to have been obtained, and certain text-books quoted these statements as facts.

By the investigations made in the "Challenger," the contour lines at each 1,000 fathoms of depth were for the first time drawn with some degree of accuracy, and it was shown that the great depths formerly reported had been much exaggerated. Soundings of upwards of 3,000 fathoms were seldom found, and the deepest cast was 4,475 fathoms in the neighbourhood of the Mariana Islands. The investigations undertaken at the same time by the United States confirmed the results obtained in the "Challenger," which the subsequent experience of twenty years has shown to be correct; the many soundings obtained by other vessels since the expedition returned to England have not altered in any material degree the contour lines originally drawn by the officers in 1876, or resulted in the discovery of any depth exceeding five statute miles. Consequently, 4,500 or 4,600 fathoms may be fairly accepted as the extreme oceanic depth.

3. The laborious work of obtaining ocean temperatures at a

depth of each 100 fathoms from the surface to the bottom, and at every 10 fathoms to a depth of 200 fathoms, enabled diagrams to be constructed showing the vertical distribution of temperature in all the great ocean basins. These determinations furnished a standard of reference for subsequent observations, which have confirmed, in a remarkable manner, the results of the "Challenger" Expedition, and have shown that, at depths exceeding 100 fathoms, the temperature is either constant, or the change is so small that it cannot be recorded in a period of twenty years.

4. Early in the voyage it was remarked that over certain areas the bottom temperature remained constant. Thus, in the eastern part of the North Atlantic the temperature at all depths exceeding 2,000 fathoms was constant at 36.8° Fahr., whilst in the western part it was 0.5° lower. Subsequent experience in the North Pacific showed that the bottom temperature was constant at 35° ; in the China Sea it was 36.8° ; in the Sulu Sea, 50.5° ; in the Celebes Sea, 38.7° ; and in the Arafura Sea, 38.6° ; whilst in the south-western part of the South Atlantic the temperature at the bottom fell to 32.7° —and previous results obtained in the "Porcupine" gave a minimum of under 30° for the bottom temperature to the north-eastward of the Faeroe Islands in the North Atlantic. These results were finally shown to be caused by certain oceanic areas being separated from each other by submarine ridges, which prevent the spreading to low latitudes of the cold bottom water existing in, or near, the polar basins.

In connection with these results it is worth noticing that no bottom temperature was obtained as low as the freezing point of salt water, and that the only temperature hitherto recorded which is near the point of maximum density of sea-water (25.4°) is that obtained in the voyage of Sir John Ross to the Arctic in 1818. Also that the bottom temperature of the Red Sea is constant at 69° , and of the Mediterranean at $55\frac{1}{2}^{\circ}$.

5. The "Challenger" was provided with twelve chronometers, and careful observations were made at each place touched at, and the meridian distance between each place calculated. The longitude of some of the islands in the Southern Indian Ocean was proved to be twenty minutes or upwards in error. The total of the meridian distances round the world amounted to $360^{\circ} 7'$ —an error of seven minutes in a voyage lasting three-and-a-half years, during which the chronometers had been exposed to great differences of temperature, and the length of time occupied between the ports had necessarily been much lengthened in order that the special work of ocean exploration might be properly performed.

6. Although the "Challenger" was not specially employed for surveying work, advantage was taken of the vessel's stay at any port to survey the anchorage, or add to the chart already existing. Thus, in the course of the voyage, an elaborate survey was made of the space enclosed by the mole at Gibraltar, plans were made of

Porto Grande, St. Vincent; of Ngaloa Bay in the Fiji Islands; and of Nares Harbour in the Admiralty Islands; Kerguelen Island was partially surveyed, and positions selected for the observations of the transit of Venus; Heard and MacDonald Islands were sketched in as the ship passed; the extent of the coral bank surrounding the Bermudas was determined, and a new coral bank to the south-westward of that group discovered; and so on.

7. Observations for the determination of the set of the currents in the ocean, when circumstances were favourable, were accurately obtained (1) by anchoring a boat by means of the dredge, or trawl, and (2) by lowering a drag to various depths, and determining the drift of this drag from the boat at anchor. This is the only way in which these observations can be accurately made, and, so far as is known, the "Challenger" Expedition alone has adopted these means.

T. H. TIZARD.

II.—OCEANIC CIRCULATION.

THE series of memoirs on the physics and chemistry of the voyage of H.M.S. "Challenger" is fitly concluded by an *Appendix* dealing with the circulation of waters in the great oceans, by Dr. Alexander Buchan. Since this has only just been published, we give a more detailed account than is required by the other memoirs. This report consists primarily of sixteen maps, on which are exhibited the distribution of temperature and salinity at various depths, so far as made known to us by the observations of the "Challenger" and of a number of subsequent deep-sea expeditions. Our information is unfortunately still insufficient to allow of the construction of maps showing salinity at any level except the surface; but Dr. Buchan has drawn very complete isothermal charts of the mean temperatures at the surface, at every hundred fathoms up to 1,000, and at 1,500 fathoms; and more isolated observations are charted for temperature at 2,200 fathoms, and for temperature and salinity at the bottom where the depth exceeds 1,000 fathoms. Some forty pages of letter-press are devoted to a general account of the temperature phenomena disclosed by the maps, and of the probable oceanic circulation suggested by them.

It is scarcely possible to over-estimate the scientific value of the information set forth in this report, which may be regarded as the first serious attempt to represent as a whole the distribution of temperature in the great water-masses of the globe. Nearly thirty years ago Dr. Buchan published his classical memoir on the distribution of atmospheric pressure over the earth's surface, and it cannot be doubted that the present work will take a place amongst oceanographers similar to that occupied by the former amongst meteorologists. As Dr. John Murray points out, the results as far as now ascertained show the urgent need for further exploration in the Southern Ocean, the western half of the South Atlantic, and the Pacific from about

150° W. long. to the American coasts, and there are elsewhere serious gaps in the observations both of temperature and salinity. But from the nature of the case we must expect the growth of our knowledge of the depths of the great oceans to be slow; and it is, therefore, all the more satisfactory that it is now possible to obtain such a general view of average conditions as will enable us to appreciate the bearings of detailed studies over restricted areas.

In meteorological work, where temperatures below freezing are of common occurrence, and where isobaric and isothermal charts are frequently used for purely practical and unscientific purposes, there is much to be said for the retention of the Fahrenheit scale; but in an inquiry of this kind, which appeals almost exclusively to scientific specialists, it seems, indeed, a pity that the Centigrade scale was not adopted. Not only is it impossible to compare or combine Dr. Buchan's results with the observations of the majority of oceanographers and marine zoologists, but the transformation to the Centigrade scale must be effected before a specific gravity calculation can be made with the tables published in another part of the "*Challenger*" *Report*. It is further to be regretted that specific gravities are calculated for a temperature of 60° Fahr., and referred to pure water at 39.2° Fahr., since, in this case, the temperature difficulty could have been altogether avoided by expressing salinities in "pro milles" in the usual way. In the chart of mean annual surface temperature, areas above 60° Fahr. are coloured red, while colder areas are coloured blue, and the land is filled in with black tints; the general distribution of temperature being thus made abundantly clear at a glance. At the depths down to 1,500 fathoms a different method is followed,—the sea area is tinted according to depth, and only the isothermal lines are drawn, these being blue or red in each map according as they represent a temperature below or above the average of all the observations employed in drawing them. We could have wished that it had been possible to combine the undoubted advantage of representing the relation of the temperature at any part of a horizontal plane to the mean for the whole of that plane, with a uniform scheme of colour like that given on the surface chart; for the change of colouring in each map makes it difficult to form a clear mental picture of the vertical distribution between one plane and another. Further, the fact that the contour-colouring in all the maps is identical leads to confusion between open areas and closed basins, especially as in many cases the lines are drawn free-hand so as to show the temperature at a depth which, according to the contour map, does not exist. This difficulty could have been got over by representing, for example, the whole area within 500 fathoms of the surface as *land*, in the maps of planes below 500 fathoms, and so on.

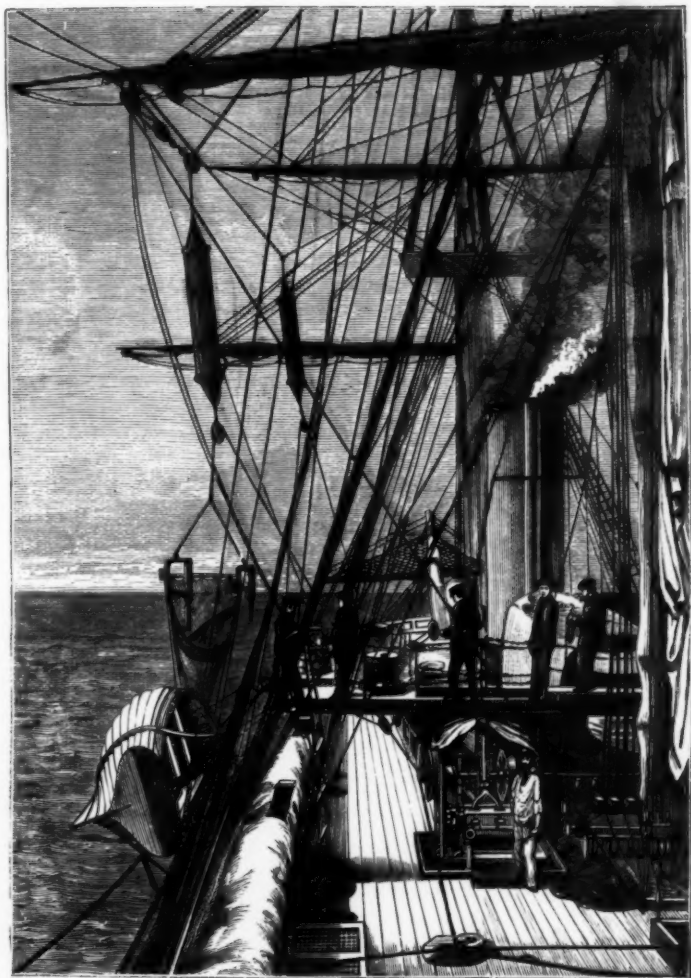
Perhaps the most interesting feature of the map of mean specific gravity at the surface is the relation of the areas of highest salinity to the great ocean anticyclones. The maximum evaporation occurs, as

has been shown by Krümmel and Schott, where the winds are strongest and steadiest, and we accordingly find the densest surface waters in the regions of the great permanent winds; the typical examples being those of the trade winds in the North and South Atlantic. Comparing this map with that of mean annual surface temperature, it appears at once that the areas of highest temperature do not in general coincide with those of greatest salinity, but that over the latter there is usually a considerable gradient of temperature from one side to the other. Hence, we derive the important result that the heaviest water occurs very much on the polar sides of the areas of maximum salinity, and that so far as gravity alone is concerned we must expect to find there the chief tendency for the water to sink below the surface, a fact which may come to be of vital interest in connection with the distribution of animals. Space does not permit us even to mention the many points of great interest suggested by Dr. Buchan's map of surface salinity; we may merely observe that in the case of the North Sea and the East Indian and Chinese waters it proposes a distribution markedly different from that hitherto accepted. With reference to the latter, great stress is laid on the influence of rainfall in lowering the salinity of the surface waters, and we must confess to some difficulty in following Dr. Buchan's explanation, especially in view of Schott's observations and experiments in this very region.

In constructing the temperature maps for the depths, Dr. Buchan states that after full investigation for intermediate depths down to 200 fathoms, the plane of 100 fathoms was recognised as being beyond the limit of seasonal variation; single observations are accordingly accepted as mean temperatures. We hope Dr. Buchan may be induced to publish the maps to which he refers; for a complete knowledge of seasonal variations, to the greatest depth at which they occur in the open ocean, is of first importance in discussing the circulation of waters in closed areas. We know, for example, that temperature in the Faeroe Channel is not constant even at a depth of 400 fathoms, and it is probable that variations in the strength of the current flowing over the Wyville-Thomson ridge are in part responsible for great changes of temperature and salinity in the North Sea and the Baltic.

The mean temperatures, for all the oceans, at the different levels, are given as follows, and show an average vertical curve of extreme interest:—

Depth in fathoms.	Temperature in degrees Fahrenheit.	Depth in fathoms.	Temperature in degrees Fahrenheit.
100 ..	60·7	900 ..	36·8
200 ..	50·1	1000 ..	36·5
300 ..	44·7	1100 ..	36·1
400 ..	41·8	1200 ..	35·8
500 ..	40·1	1300 ..	35·6
600 ..	39·0	1400 ..	35·4
700 ..	38·1	1500 ..	35·3
800 ..	37·3	2200 ..	35·2



DREDGING AND SOUNDING ARRANGEMENTS ON BOARD THE "CHALLENGER."





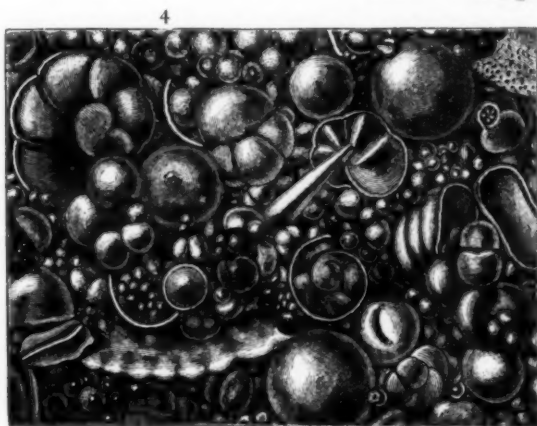
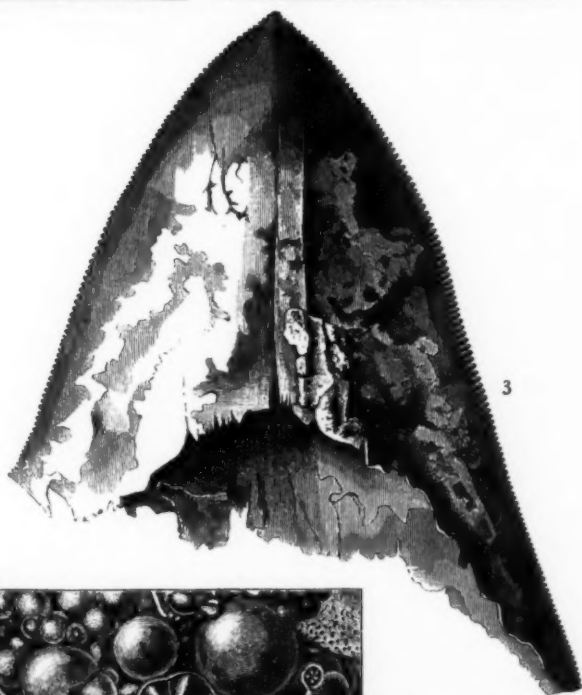
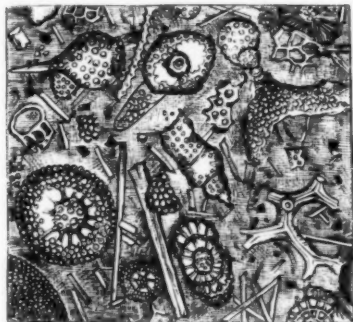


Fig. 1. Radiolarian Ooze, Central Pacific, 4,475 fms. $\times 100$.

Fig. 2. Diatom Ooze, Antarctic Ocean, 1,900 fms. $\times 200$.

Fig. 3. Tooth of an extinct species of *Carcharodon*.

Fig. 4. Globigerina Ooze, North Atlantic, 1,900 fms. $\times 50$.

DEEP-SEA DEPOSITS.





In the Atlantic and Pacific Oceans the controlling influence of the great anticyclones of the lower latitudes is very clearly seen even at great depths. Circulation is, of course, most active in the Atlantic, partly because the belt of calms between the trades is at all seasons north of the equator, and the trades themselves blow with greater force and persistency than in the Pacific, and partly because the configuration of the land is such that the horizontal movements of water at and near the surface are suddenly arrested, and the increased pressure due to the heaping up of the waters is in part relieved by vertical movements downwards. One important effect of the position of the belt of calms is that immense quantities of warm surface water are transferred bodily from the South to the North Atlantic, with the result that so far as temperature is concerned the two oceans stand in strong contrast to each other even at great depths. A comparative study of the distribution of temperature in the Atlantic and Pacific Oceans strongly impresses upon us the truth of Mr. Buchanan's remark, recently emphasised by Admiral Wharton, as to the extreme slowness of the vertical movements of oceanic waters when the action of gravity is left to work alone. If we take a sea-water of average density, 1.0260 at 60° Fahr., its density at 45° Fahr. is 1.0275, and at 67° Fahr. 1.0250; so that the same water can cover the whole range of density found in the Atlantic by a temperature variation of 22° Fahr. Hence, even the saltiest surface-waters can only penetrate the layers underlying them after having been cooled by a process of mixture, which has probably robbed them by dilution of the greater part of the extra salinity; and we are forced to the conclusion that when strongly-marked vertical movement occurs it must, in most cases, be ascribed to differences of pressure acting at the surface.

In the latter part of his discussion Dr. Buchan treats the Gulf of Mexico, the Mediterranean, the Red Sea, the Persian Gulf, the Indian Ocean, the Arctic Ocean and Norwegian Sea, and the Southern Ocean under separate headings. Outside the Atlantic and Pacific, interest naturally centres in the last-named, with which is inseparably bound up the Indian Ocean. The rigours of the unknown Antarctic are kept within bounds by the vast quantities of heat sent southward from the Brave West Winds and their following currents. At the surface the icy fingers are only visible here and there across the surface of the warm drifts, but underneath, 1,500 fathoms down, the creeping cold can be seen making its way northwards.

H. N. DICKSON.

III.—GEOLOGY.

GEOLOGISTS received from the "Challenger" a great mass of facts concerning the deposits now forming in the depths of the ocean; their interest was again markedly aroused in the problems of coral-reefs and the solution of limestone; while for the discussion of those

wider problems of the permanence of ocean basins and general world-architecture, they have been provided with new and important documents. All these questions have already been fully discussed in *NATURAL SCIENCE* by persons competent to express an opinion. In our first number the Report on Deep-sea Deposits was reviewed at length by Mr. Harris Teall, and the exploration of coral-reefs was dealt with by Dr. J. W. Gregory. In August, 1892, Dr. Russel Wallace criticised the views as to the permanence of ocean basins that Mr. John Murray had based on the work of the "Challenger"; while Professor Edward Suess was so good as to give English readers his opinions on the same subject in our number for March, 1893. We have now asked Professor Judd to set forth the present answer of geologists to the questions concerning coral-reefs raised by the "Challenger" Expedition; and, as circumstances have unfortunately prevented the Abbé Renard from fulfilling his promise to contribute, two of Mr. Murray's fellow-workers have most kindly supplied notes on the deep-sea deposits and the problems they have raised.

CORAL-REEFS.

Previously to the expedition of the "Challenger," two naturalists had expressed doubts as to the universal application of the "subsidence-theory" of coral-reefs—a theory first propounded by Darwin, and afterwards very ably supported by Dana. In 1863, Semper showed that, in the Pelew Islands, there are found in close proximity to one another upraised reefs and atolls; while J. J. Rein, in 1870, argued that the phenomena displayed in the Bermudas point to far more complex conditions than those postulated in the theory of subsidence.

It is an unquestionable fact, however, that it was mainly owing to the important observations made on board the "Challenger" with respect to the nature and mode of accumulation of the deep-sea organic deposits, that a wide-spread feeling of doubt as to the adequacy of the subsidence-theory of Darwin began to be manifested among zoologists, and to a less extent among geologists also. It is not necessary, here, to detail the various contributions to this important question made by Dr. John Murray, and subsequently by Prof. A. Agassiz and other zoologists. A very clear and impartial statement of the arguments adduced on either side of the question, down to the year 1889, will be found in the appendix drawn up by Professor Bonney for the third edition of Darwin's "Coral-Reefs." Since 1889 there have appeared two other very important works dealing with the whole question, namely, the third edition of Dana's "Corals and Coral-Islands," and Dr. Langenbeck's "Die Theorien über die Entstehung der Koralleninseln und Korallenriffe und ihre Bedeutung für Geophysischen Fragen."

The geological bearings of the observations made upon existing coral-reefs have been made the subject of several important memoirs,

chief among which we may mention those of Sir Archibald Geikie (*Proc. Edinb. Roy. Phys. Soc.*, vol. viii., 1883, p. 1.) and of the late Professor James D. Dana (*Amer. Journ. Sci.*, 3rd ser., vol. xxx., 1885, pp. 89, 168; also in *Phil. Mag.*, ser. 5, vol. xx., 1885, pp. 144, 269). During the last few years additional interest has been added to the discussion upon coral-reefs, in their geological aspect, by the discovery of a number of undoubted deep-sea organic deposits, such as Globigerina ooze and Radiolarian ooze, among the rocks of the earth's crust, some of which, though of late Tertiary age, have been elevated several thousands of feet above the sea-level. These facts have, of course, tended to confirm the views of those geologists who maintain that great interchanges must have taken place in past times between the continental and oceanic areas of the globe.

Within the last two years two most important monographs on coral-reefs have made their appearance, Mr. W. Saville Kent's "The Great Barrier-Reef of Australia," and Professor Alexander Agassiz's admirable description of the Bahamas¹, the authors arriving at very opposite conclusions on the general question of the origin of coral-reefs, from their careful and detailed studies of these interesting examples.

In connection with the latter of these memoirs, a melancholy interest attaches to the circumstance that it was the perusal and notice of his friend's monograph that occupied the distinguished American naturalist, James Dwight Dana, during the last few days of his life. From the charming and judicious sketch of his father's life and career, written by Professor E. S. Dana, we learn that the notices of books in the May number of the *American Journal of Science* were the last literary work undertaken by the great naturalist, and the views that he enunciated as the final result of his wide experience and his latest reflections on these important questions deserve to be widely known. We shall not, therefore, apologise for transferring them to these pages.

"Professor Agassiz, in discussing the origin of coral-reef limestones, states objections to the subsidence-theory of Darwin. Without touching here on the special arguments in its favour, two or three general facts may be stated.

"In geological history, many limestones have been made exceeding 1,000 feet in thickness, which show by their fossils that they are not of deep-water origin. Whether derived from coral and shell sediment like coral-reef rock, or from shell sediment chiefly, makes no difference; subsidence was required.

"Subsidences of one or two scores of thousands of feet in depth have taken place in past times over the region of the Appalachians, Alps, and other mountain regions; and in the sinking trough, sediments were formed successively at the water's level, or not far

¹ "A Reconnaissance of the Bahamas and of the Elevated Reefs of Cuba, in the steam yacht 'Wild Duck,' January to April, 1893," with 47 plates. *Bull. Mus. Comp. Zool.* Vol. xxvi. Number 1; December, 1894.

below it, to the thickness of the depth of subsidence; and some of the sediments were calcareous, making now thick limestone strata.

"After the Cretaceous period, and in the Pliocene Tertiary chiefly, or the Tertiary and Glacial period, the whole region of the Rocky Mountains was elevated; the elevation was 16,000 feet in part of Colorado, 10,000 feet, at least, in the region of the Sierra Nevada, 10,000 feet in Mexico, and over 17,000 feet in British America, latitude 49° to 53° , and less to the north. The region of the Andes, at the same time, was raised to a maximum amount of 20,000 feet; the Alps, 12,000 feet; and the Himalayas, 20,000 feet. Moreover, at the close of the Champlain period there was another epoch of smaller elevation, introducing the recent period. These elevations, affecting a large part of the continental areas, could not have taken place without a counterpart subsidence of large areas over the oceanic basin; profound oceanic subsidence was hence in progress during the growth of coral-reefs. The subsidence cannot be questioned."

In these remarks Dana has forcibly dwelt on the facts which greatly weigh with geologists in inducing them to accept the "subsidence-theory" of coral-reefs. That the questions involved in the explanation of the numerous examples of coral-reefs in different oceans are much more complicated, than was at one time suspected, they freely admit; but with such clear evidence as they possess of subsidence and deposition having gone on concurrently, until deposits thousands of feet in thickness were piled up, geologists find it difficult to believe that coral growth was the one form of organic accumulation that did not conform to this common rule. Important and valuable, then, as were the observations made upon coral-reefs by the officers of the "Challenger," geologists still feel that many more exact studies of these wonderful structures require to be made, before the problems connected with their origin can be considered as finally settled.

JOHN W. JUDD.

CHEMICO-BIOLOGICAL CHANGES IN THE OCEAN.

THE investigations conducted by the "Challenger" Expedition with reference to the distribution and composition of oceanic deposits over the floor of the ocean have led directly to a number of interesting researches, undertaken with the view of throwing some light on the chemical changes now taking place in the ocean under the influence of organisms and organic matter. The results are contained in a series of papers by Murray, Irvine, Woodhead, Young, Gibson, and Anderson, published in the *Proceedings and Transactions* of the Royal Society of Edinburgh, from 1888 to 1894.

These researches appear to explain some of the phenomena connected with the distribution of calcareous and siliceous organisms in different depths and regions of the ocean, as well as certain peculiarities of the different varieties of deposits. The results of these investigations may be briefly summarised.

A series of experiments were carried out with hens and crabs in order to determine whether or not they were dependent on the

actual presence of carbonate of lime for the formation of hard calcareous egg-shells and tests respectively; and it was found that, provided lime was present in their food, in such forms as phosphate, silicate, sulphate, or nitrate, the animals found no difficulty in forming a sufficiency of carbonate of lime for their shells and tests. No shells were formed when salts of strontium or magnesium were substituted for lime salts. The formation of carbonate of lime is presumably due to the influence of ammonium carbonate, one of the ultimate products of the decomposition of excreta. This was so far confirmed in that the addition of ammonium carbonate to sea-water resulted in a precipitate having the same composition as that of corals and shells.

The separation of such a precipitate took place much more rapidly at a high temperature (80° Fahr.) than at a low (as 35° to 40° Fahr.). This may explain why in tropical latitudes the secretion of carbonate of lime by organisms is much more abundant than in polar waters, as, for instance, by corals, molluscs, foraminifera and algæ.

Diatoms were experimentally shown to be capable of forming siliceous tests when grown in water in which fine clayey matter was suspended; and it is interesting to note in this connection that such siliceous organisms occur in greatest abundance in those regions of the ocean in which there is a large admixture of fresh water holding in suspension detrital matter from the land; for instance, near river mouths, the Polar regions, and the North-west Pacific, where the power of the water of holding matter in suspension is, from its low specific gravity, relatively great. It is thus probable that marine siliceous organisms do not depend, wholly at least, upon the silica in solution in the sea for their skeletal parts, as has been generally held.

The blue muds laid down in the proximity of the land are comparatively rich in organic matters, the decomposition of which initiates, in the circumambient sea-water, the reduction of the sulphates to sulphides and carbonates, thus increasing the alkalinity of the sea-water associated with the muds. This increased alkalinity lends to the water an additional power of decomposing the sedimentary material on the bottom, and in this way brings about numerous chemical changes, such as the formation of zeolites, phosphatic and manganese nodules, and glauconite. As iron is a constant constituent of these deposits, the ultimate result of the chemical changes is the formation of sulphide of iron, giving to these muds their characteristic bluish-black colour. In the same way sulphide of manganese is formed in these muds; but, unlike the sulphide of iron, it is decomposed by carbonic acid, forming soluble manganese bicarbonate, which remains in solution until it meets with an excess of oxygen, as in the water overlying the mud or on the surface of current-swept ridges. It is then precipitated as a higher oxide of manganese, which may again be reduced, go into solution, and be re-precipitated elsewhere. There will obviously tend to be an

accumulation of manganese in any region which is peculiarly free from reducing matter, as over the red-clay areas of the great ocean basins. These phenomena have been adduced to explain the formation of manganese nodules and concretions. (Pl. xv. Figs. 1 and 2.)

Attempts have been made towards the explanation of the formation of dolomites. The fact that corals placed in a solution of copper sulphate become superficially converted into pseudo-morphic copper carbonate, hinted at a possible solution, viz., that the dolomites arise by the interchange of magnesium and calcium in lime formations when exposed to such a solution of magnesium salts as occurs in modern seas. To test this a *Tridacna* (Giant Clam) shell, whose great age was attested by its size, was examined chemically in various parts, with the result that the outside or oldest part was found to be much richer in magnesia than the inside or more recent formation.

ROBERT IRVINE.

MARINE DEPOSITS.

The researches of the "Challenger" gave the first definite information regarding the sediment now accumulating in various regions and depths on the ocean floor. A study of the "Challenger" collections, together with those made by subsequent deep-sea expeditions, has enabled Messrs. Murray and Renard to give a comprehensive sketch of the composition and distribution of these deposits, which has proved of the highest interest to geologists and physical geographers.

The marine accumulations are divided into two great classes—**Terrigenous Deposits** and **Pelagic Deposits**. (See Plate iii.)

The Terrigenous Deposits are those formed in shallow and deep-water close to the shore, and are mostly made up of mineral particles and detrital matters washed down from the dry land by rain, or torn from the coasts by the action of waves and currents. Their peculiarities are thus determined by the character of the adjacent land. Blue Muds prevail in enclosed seas and off the mouths of large rivers, while off bold coasts Green Sands and Muds with much glauconite are more abundant; off volcanic islands are Volcanic Sands and Muds, while off coral islands Coral Sands and Muds are found. The rock-fragments and mineral particles diminish in size and abundance with increasing distance from land, and it may be stated generally that, at an average distance of 200 miles from the shore, particles of quartz and other continental minerals exceeding .1 mm. in diameter rarely make up any appreciable part of the deposit, except in those regions affected by floating ice. Thus, at their seaward margin, the terrigenous deposits pass gradually into pelagic deposits.

The character of the Pelagic Deposits is determined by the conditions prevailing at the surface of the ocean, since they are largely made up of the shells and skeletons of pelagic organisms. In tropical

and sub-tropical regions, far removed from land, the deposits are, except when the depth is very great, chiefly composed of the shells of calcareous organisms, forming the Pteropod and Globigerina oozes. Towards the Antarctic regions, and in the Central and North-west Pacific, the deposits often largely consist of the remains of siliceous organisms, forming the Diatom and Radiolarian oozes. In the very greatest depths of the ocean the calcareous shells of the Pteropod and Globigerina oozes are sometimes entirely removed from the deposits by the solvent action of sea-water, and there is then found the peculiar Red Clay of the oceanic deeps.

The principal constituents of the Red Clay are silicate of alumina and the oxides of iron and manganese, which appear to be largely derived from the disintegration of pumice and volcanic dusts. These volcanic materials appear for the most part to have had their



FIG. 1.—SIFTING DEPOSITS.

origin in subaerial volcanic eruptions. Associated with these Red Clays the "Challenger" frequently procured, in a single haul, hundreds of sharks' teeth, some of them of gigantic size and apparently belonging to extinct species, dozens of ear-bones and other bones of whales, large numbers of manganese nodules, zeolitic minerals apparently formed *in situ*, and magnetic spherules containing native iron, nickel, and cobalt, and believed to be of cosmic origin. The remarkable association of these organic and inorganic materials in the Red Clays seems to indicate an extremely slow rate of accumulation, which is the more marked the further these deposits are removed from continental land.

Chemical changes take place in all the deposits, giving rise to secondary products, such as phosphatic and glauconitic concretions in

the Green Muds, sulphide of iron in the Blue Muds, siliceous and calcareous concretions in the calcareous deposits, and manganese-iron nodules and zeolitic minerals (phillipsite) in the Red Clays.

The following table, given by Messrs. Murray and Renard, shows the mean depth, mean percentage of carbonate of lime, and the estimated area of the various deep-sea deposits.

	Mean Depth in Fathoms.	Mean Percentage of CaCO ₃ .	Area, Square Miles.
Red Clay	2,727	6.70	51,500,000
Radiolarian Ooze	2,894	4.01	2,290,400
Diatom Ooze	1,477	22.96	10,880,000
Globigerina Ooze	1,996	64.53	49,520,000
Pteropod Ooze	1,118	79.26	400,000
Coral Sands and Muds	710	86.41	2,556,800
Other terrigenous deposits, Blue Muds, etc.	1,016	19.20	16,050,000

J. CHUMLEY.

IV.—BOTANY.

It is a pity that the "Challenger" staff did not, as was originally suggested, include a botanist, qualified to observe and collect, who might have devoted the whole of his time to his own subject. This is no disparagement of the excellent services rendered by Moseley, whose interesting notes supply some of the most readable and instructive pages to the ponderous vol. i. on *Botany*. As Mr. Clarke points out, this includes much more than the Botany of the "Challenger" Expedition. In it Mr. Hemsley has got together from many various sources the facts relating to the history of insular floras, while, in the lists of plants, the material of our national herbaria has been used, dating as far back as some of the collections acquired by Sir Hans Sloane, now one of the most cherished possessions of the British Museum. To the Keeper of the Botanical Department in that Museum we are indebted for the following notes on—

THE MARINE FLORA.

The shore Algæ collected by Moseley during the cruise of H.M.S. "Challenger" were worked out by the late Professor Dickie, and published in the *Journal of the Linnean Society* as he received the collections from different localities. Professor Dickie's herbarium, now in the British Museum, was a good one, but not quite good enough for the purpose of determining with accuracy collections from so wide an area as that covered by H.M.S. "Challenger," and the result is that a number of the names do not stand. It was, however, an excellent piece of work, and as well done as it could have been outside the herbaria of the British Museum, Kew, or Dublin. Not many new species were added, but we have learned from these collections all we know of the marine flora of the small islets of the Southern Ocean. The "Transit of Venus" Expedition to Kerguelen Island added to our knowledge in that particular case. Considering

Moseley's other duties on board and other interests, it is a remarkable collection—as good a collection as would have been made by most young botanists with nothing else to do. The other sources of the Algæ collected were not of so much geographical interest; but in all cases the results have been welcome.

The main interest, however, of the expedition to botanists is in the light shed on the Algæ of blue water—the plankton Algæ of the open sea, removed from the influence of coast and river waters.



FIG. 2.—*Pyrocystis noctiluca*, Murray;
100 times nat. size.

This expedition first taught us the great extent of this flora, though observations, such as those of Sir Joseph Hooker in the Southern Ocean, of Dr. Wallich, and others, had led botanists to expect the existence of a universal pelagic flora. Dr. John Murray's observations, published in the *Narrative* and in the *Summary*, are by far the most important contribution to our knowledge of the distribution of these forms; and the recent Hensen Expedition has added but little to it. How-

ever, all that has yet been done in the study of this flora is to advertise its existence, and to proclaim to botanists the urgent need for its exploration. The marine Peridiniæ, *Pyrocystis* (Fig. 2), the Coccospheres (Fig. 3) and Rhabdospheres, and other forms like *Halosphæra*—noted but not yet described—all need working out. The Cyanophyceæ and Diatoms are, perhaps, of less biological interest at present; but much has yet to be done with them too. Castracane's report on the Diatomaceæ (*Botany*, vol. ii.) has added a great number of new species to the overwhelming number already existing—and it has been criticised with some severity by experts—but it, together with Mr. Comber's hard work contributed to the *Summary*, forms a notable addition to our knowledge of these forms and their distribution.



FIG. 3.—A Coccosphere; 1,000 times nat. size.

The expedition has, then, not only made a great advance in our knowledge of the flora of the sea, but it has made exact and calculated work possible in the future. It has pointed out unmistakably what the next marine expedition has to do—whether it leave our shores for the Antarctic seas, or be a mere traverse of the Atlantic for biological purposes.

GEORGE MURRAY.

THE LAND FLORA.

The object of the voyage of the "Challenger" was "to investigate scientifically the physical conditions and natural history of the deep sea all over the world." Among the scientific staff on board was no one specially set aside to collect plants and make botanic observations. H. N. Moseley was appointed as a zoologist, but he was more than a zoologist—he was a naturalist; indeed, though he did not profess botany, he had a considerable technical knowledge of the subject and an intense interest in the wider problems of geographic and geologic distribution on which botany throws special light. He took his own view of his duties from a study of the Naturalist of the "Beagle." At the end of his "Notes of the Voyage" he summarises in these words: "The deep sea, its physical features, and its fauna, will remain for an indefinite period in the condition in which they now exist, and as they have existed for ages past with little or no change, to be investigated at leisure at any future time. On the surface of the earth, however, animals and plants and races of men are perishing rapidly day by day, and will soon be, like the Dodo, things of the past. The history of these things once gone can never be recovered, but must remain for ever a gap in the knowledge of mankind. . . . Insular floras and faunas will soon pass away." With these views, Moseley worked his hardest while the "Challenger" was in harbour; out of the three-and-a-half years' cruise he got 520 days on shore. But a very large portion of this time was spent in well-inhabited ports, such as Funchal, Bahia, Melbourne, which afforded no specially favourable opportunity for study of the indigenous element of the flora. The Admiralty Islands he was the first to explore botanically, and he collected 69 species although he only got a week there; nor did he get a longer stay at the interesting Marion group, where he was also the earliest collector. In such short visits a botanist can only collect the plants of one season of the year found on a fraction of the area.

Moseley by no means confined his botanic work to collecting; in his Notes are recorded numerous observations, especially with reference to the transport of new species of plants to an oceanic island. He notes the arrival in the sea of the beans of *Guilandina Bonduc*, and their growing into shrubs on the sea-shore of West Indian islands. He also noted that large trees float in the sea laden with earth, so that some branches remain altogether in the air; on

these fruits and seeds may be carried considerable distances by sea without any immersion in salt water; in this he advanced a step on Darwin.

The "Challenger" returned home in May, 1876; the zoologic collections were handed to specialists for study and description. Moseley's collections were sent to Kew and simply placed in the herbarium. Most of the islands at which he had collected had been previously visited by professed botanists: as St. Helena by Roxburgh and Burchell, the Falkand, Kerguelen, and many other islands in the Southern Ocean by Sir J. D. Hooker; and of these more complete floras already existed than the collections and notes of Moseley could furnish. The publication of Phanerogamic Botany in the *Report* of the voyage could hardly have been contemplated in the original official instructions; and it was only seven years after the collections had been stored at Kew that, on the recommendation of Sir J. D. Hooker, himself the leading authority on Insular floras, the task of preparing a report on the botany of the "Challenger" Expedition, *to be restricted to Insular Floras*, was entrusted to W. B. Hemsley. The reports on Algæ, Diatoms, etc., being largely on marine species, were made by specialists; Mr. Hemsley's work, with its inferences, is on the Phanerogams and Vascular Cryptogams of the islands visited; he drew up lists of these plants for Bermuda, Fernando-Noronha, Ascension, St. Helena, Trinidad, Tristan da Cunha, the Prince Edward group, Amsterdam and St. Paul, Juan Fernandez, Aru and Ke Isles, and Admiralty Isles; he tabulated these, showing their distribution in the nearest islands or continents, and discussed with numeric percentages and detail their affinities, indigenous character, or manner of introduction. In doing this work, Hemsley availed himself of all the previous collections and preceding writings, so that, in several cases, the collections and notes of Moseley supply but a fraction of the material worked up and discussed by Hemsley in the *Botany* of the "Challenger."

In restricting this report to insular floras, due regard was paid to the opinion which Moseley had himself expressed on the important deductions to be derived from them concerning the distribution of plants. This is especially true as regards the remoter islands little visited by man. In many islands, the indigenous vegetation has been almost wholly destroyed by him, and by the animals he has brought, while weeds have been plentifully introduced; where he has deserted his wasteful plantations, the weedy scrub, which has sprung up, in no wise resembling the primæval forest, is of no botanic interest. At the same time, it is highly instructive to discover exactly the route by which the new weeds arrived; there will too often remain a doubt as to many plants—whether they are indigenous or not. Islands lend themselves very kindly to Hemsley's tabulation in that they provide definite areas; if we begin to tabulate the "Cape Flora," our option where we choose to draw the

boundary line of the "Cape" affects all our numeric results with large plus and minus possibilities of error.

The first and principal botanic gain, therefore, from the voyage of the "Challenger" has been the Report on Insular Floras, by W. B. Hemsley. It is not easy to epitomise his results shortly; one general result is the extent to which he has got rid of previously admitted anomalies. We find, for instance, in some large genus, a multitude of closely-allied species dotted about in the most "anomalous" manner in various oceanic islands and their nearest continents. But, as Mr. Hemsley observes, when all the material comes into the hands of one competent man, he unites some species, refers some specimens differently, and, finally, brings out a perfectly clear and consonant result. Mr. Wallace found the vegetable productions of Madagascar to be less like those of Africa than those of England are to those of Japan. The result of fuller knowledge is that the Madagascar flora is much more closely allied to that of Africa than to that of Asia or Australia; the ratio of similarity between the flora of Madagascar and that of any other continent follows the law of the inverse square pretty closely; if it did not we should have to look for prevalent winds or permanent oceanic currents to explain the anomaly. We may almost venture to write "human ignorance" in lieu of "anomalies in distribution." If we knew all the geologic history in addition to the causes at work, we ought to be able thereout to arrive at the existing distribution; the explaining away of an anomaly is the triumph of science. Hemsley has got rid of some formerly-received generalisations that formed very broad anomalies, and great obstacles to real progress. Thus it was believed that, in insular floras, the proportion of endemic species and of endemic genera was larger than in any continental areas. This it appears is not the case; in the flora of West Australia, or of the Cape, the endemic character of the flora is as strongly marked as in St. Helena or the Sandwich Isles.

One good step leads to another; Moseley's devoted labours led to Hemsley's Insular Floras. This has influenced numerous researches in the same field by H. O. Forbes, Guppy, Prain, Treub, J. Kirk, Cheeseman, Vasey, Rose, Christ, Bolle, Urban. The literature has already attained voluminous proportions.

One moral suggests itself, viz., that every future scientific expedition must have with it *either* a botanic specialist *or* a naturalist of the wide views and power of work of Moseley—such a man may be difficult always to find. But even Moseley could have given but a fraction of his mind to a subject more than sufficient to occupy completely a good all-round botanist. The investigation of insular floras has now advanced so far that it is no longer satisfactory to set one man to collect, and another man to work up, tabulate, discuss and infer in the herbarium at home; the man who stands on the shore of the oceanic island should be himself master of his subject—

acquainted well with its literature, able to draw his inferences on the spot, and proceed from those inferences then and there to intelligently directed, not hap-hazard, observation, inquiry, and collection.

C. B. CLARKE.

V.—ZOOLOGY.

THE greatest part of the innumerable discoveries with which the "Challenger" Expedition has enriched zoology concerns the Benthos, namely, those organisms which live fixed or creeping on the bottom of the ocean. But not less remarkable or important are the discoveries made on the Plankton, namely, those animals and plants which are free-swimming or suspended on the surface of the ocean, or at different depths (*c.f.* my "Plankton-Studien," 1890). With the exception of the Deep-sea Keratosa, my own contributions to the "Challenger" work concern the Plankton, and have proved that it is just the smallest pelagic animals which possess the greatest importance for oceanic life. As I wandered for ten years through this wonderful new empire, populated by more than 4,000 species of Radiolaria, for the most part previously unknown, and as I daily admired the incredible variety and elegance of their delicate forms, I had the happy and proud sensation of the explorer who is the first to travel through a new continent peopled by thousands of new and curious forms of animals and plants.

It is now universally admitted that the celebrated voyage of the "Challenger" is the most important and the most fruitful expedition that has set out since the times of Columbus and Magellan. No future expedition to elucidate the wonderful secrets of oceanic life can produce an equal number of new facts and important discoveries. The British nation may be proud to have executed this splendid standard work, and to have given to oceanography a fixed base for all future time. Many expeditions have been sent out for similar purposes during the last century; but no single one has reached similar results. To a great extent this was the consequence of the excellent preparation and the most practical equipment of the great undertaking, also of that combination of favourable circumstances, which we call "fortune." But it resulted far more, in my opinion, from the excellent men, both in the naval staff and in the civilian staff, who executed their great work with indefatigable energy and with rare intelligence. First of all must here be celebrated Sir Wyville Thomson, as the Director of the scientific staff, and after his lamentable and premature death in 1882, his successor, Dr. John Murray, who has proved himself "the right man in the right place."

During the twelve years that I was engaged upon the "Challenger" *Report*, I had to correct the proof of 3,000 pages of letterpress, and of 230 lithographic plates, and I had to exchange with Dr. Murray, as the Director and Editor of the whole work, some hundred letters. Throughout this long time and this difficult

work, I came year by year more to admire the rare qualities of man united in Dr. Murray, which enabled him to accomplish this gigantic task; his general scientific knowledge and philosophic spirit, his practical skill and administrative capacity, and his admirable survey over all parts of his immense field. If, after eighteen years of labour, the fifty big volumes of the "Challenger" *Report*, with their thirty thousand pages of letterpress and their more than three thousand plates, have now really finished publication, the British nation may be proud of this "monumentum aere perennius," and it is in the first place indebted for its accomplishment to the singular genius of John Murray.

ERNST HAECKEL.

EXPECTATIONS AND RESULTS.

Scientific interest in the nature of the sea-bottom had been aroused by a series of earlier investigations. In 1819 Sir John Ross, dredging in the "Erebus," had brought up worms from a depth of 1,000 fathoms, and had suggested that life extended even to deeper recesses. But these results were little known to naturalists, and when Wyville Thomson, from the results of the "Lightning" Expedition, urged an extended exploration of the ocean-floor, he was unable to say certainly that life extended much below a depth of 650 fathoms. To determine the depth to which it extended and the nature of the fauna was the first zoological problem in the mind of those who organised the Expedition.

But hopes of a wider nature were entertained. It was generally believed that a large number of the sedimentary rocks had been formed at the bottom of deep oceans, and it was hoped that in the deeper parts of the existing oceans there would be found alive representatives of strange new types, and living forms corresponding to Tertiary fossils. Wyville Thomson specially insisted upon this, and there can be no doubt that it was a considerable disappointment to the naturalists to find few primitive types. No trilobites, blastoids or cystids, and no primitive vertebrates of any kind were discovered. In fact, from the point of view of connecting links, the voyage of the "Challenger" was almost barren. The most important linking animals, such as *Ornithorhynchus*, *Amphioxus*, *Balanoglossus*, *Peripatus*, and *Limulus*, are not inhabitants of the depths of the ocean.

The actual results of the Expedition were, in the first place, the discovery of a vast number of new forms, which, although they seldom added to our knowledge of the connections between existing groups, added vastly to our knowledge of the infinite variety of morphological structure among groups. As a simple extension of knowledge, the results of the "Challenger" were prodigious.

Next, the "Challenger" results laid the foundation for important conclusions as to the relative distributions of land and water at various times on the surface of the globe. The permanence of the great oceans and the enduring character of the great land masses are

conclusions that have been at least partially the result of the Expedition.

Lastly, the Expedition conclusively established the existence of life down to the deepest abysses, and did much to catalogue the kinds of animals present in the different regions of the sea.

Combining the actual results of the "Challenger" with those of later investigations, most of which, indeed, were due to the stimulus given by the "Challenger" results, we are able to define the fauna of the sea. There are three great groups of marine inhabitants: a group that drifts, a group that swims, and a group that is anchored. The first group, or *Plankton*, consists of all those frail forms that float in the waters devoid of the power of movement or at the least of the power of movement against tide and current. The *Nekton* are those animals capable of swimming against currents, and so of migrating from place to place with or against the currents as they choose. The *Benthos* are those animals and plants that are fixed to the bottom, or that can crawl over the bottom only for short distances, and, therefore, neither migrate at will nor are carried about by the set of currents. The *Plankton*, *Nekton*, and *Benthos* form three well-marked communities of organisms, each having its own characteristic forms, and, naturally, its own seasonal variations. The *Benthos* and the *Plankton* can be studied more fully, as in their case the variable and elusive factor of "will" does not come into operation.

It is, of course, to be noted that both the *Nekton* and the *Benthos* contribute to the *Plankton*. The young forms of strongly swimming creatures like fishes or cephalopods are carried about by the currents, and, at certain seasons, compose a large part of the *Plankton*; while similarly the larval stages of *Benthos*, such as starfish, mollusks, and ascidians, are also *Plankton*.

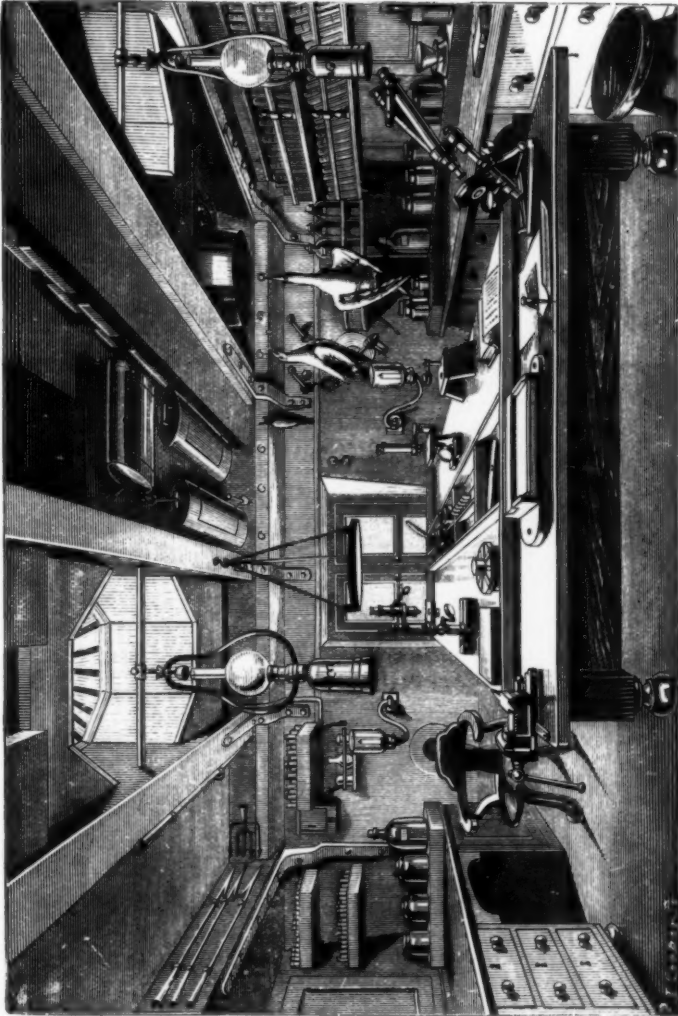
The regional classification of marine life is more difficult. The simplest region is the Pelagic zone. This extends all over the seas, from the coasts to the great oceans: its limits are difficult to define, but may be taken as practically the depth to which strong sunlight penetrates. Its inhabitants are *Plankton* and *Nekton*, and the great character separating it from deeper waters is the presence of abundant plant life. The second great zone is the Neritic zone which extends from the coast to a depth of about five hundred fathoms, excluding the superficial *Plankton*, and including the region left bare by the tides. It corresponds to the littoral region of Moseley, with the addition of the shallow banks in seas far from coasts. Its inhabitants are chiefly *Benthos*, and the great character is dependence upon the coast. The creatures of the pelagic zone differ little all over the surface of the sea, and the inhabitants of the deeper waters vary still less from ocean to ocean, but the littoral zone of each coast has its own peculiar features. The Abyssal zone extends from a depth of 500 fathoms down to the bottom of the deepest oceans. Its inhabitants are chiefly, if not entirely, *Benthos* and *Nekton*.

As we have already said, a great result of the "Challenger" Expedition, was the disproving of the existence of living fossils in the recesses of the ocean. The inhabitants of the ocean-floor are strange enough, but their strangeness is that of novelty rather than of antiquity. The great depths of the ocean are poor in species and in genera, and the species and genera are often allied to existing littoral or pelagic forms. As Moseley was among the first to point out, migration to ocean depths is a migration to an abnormal environment and could have come about only slowly. Perhaps the great ocean depths were the last parts of the surface of the earth to be populated, and their inhabitants have reached them slowly from surrounding regions. The barriers to downward migration are numerous. First there is the scarcity of food, due to the absence of vegetable life. Next there is the absence, partial or complete, of light. Again, downward currents must be excessively slow and rare, so that there would be little chance of any but *Benthos* reaching the greater depths. Lastly there is the enormous barrier of the increasing pressure of the water, as the downward migration progresses. If the "Challenger" Expedition failed to find the living fossils zoologists hoped for, it found a still more extraordinary aspect of the kaleidoscope of life.

P. CHALMERS MITCHELL.

FORAMINIFERA.

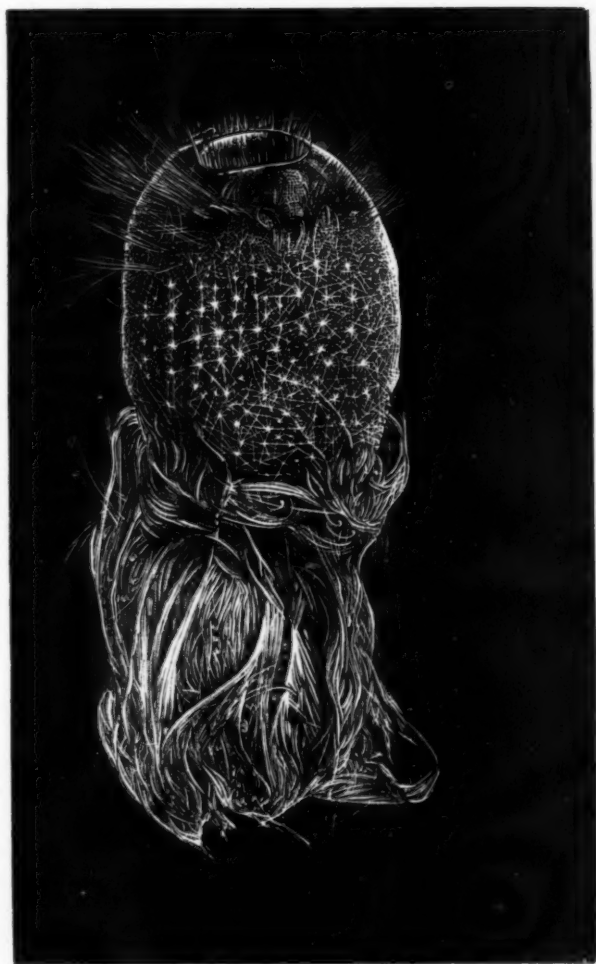
No less than 814 pages and 115 quarto plates were devoted to the Foraminifera collected by the "Challenger." The monograph was the work of Dr. H. B. Brady, whose ripe knowledge had been early trained to a due regard for the simplification of nomenclature by his collaboration and friendship with Parker and Rupert Jones. The Report on the Foraminifera will always remain the great book of reference on all the recent forms of this group; it contained the basis of a bibliography and of an index to known forms, and paved the way for a surer and more definite classification. Perhaps the most valuable and at the same time the newest of Brady's work was the careful study and description of the previously little-known arenaceous forms, some ten genera and numerous "species" being described practically for the first time. The exact locality and depth of the gatherings rendered it possible to compare the geographical distribution of the Foraminifera. Brady was thus enabled to give detailed lists of those forms which form the mass of the Globigerina ooze (Pl. iii. Fig. 4), those which form the red clay, those of shallow water, and those of pelagic habits; lists of the greatest value to workers in the geological history of the group. He gave a detailed survey of the works of previous authors on the subject, compared the various classifications, and proposed his own view, redescribing every genus and carefully confining it more exactly than hitherto, thus smoothing the way for future workers to a remarkable degree. The elaborate



ZOOLOGICAL LABORATORY ON THE MAIN DECK OF THE "CHALLENGER."



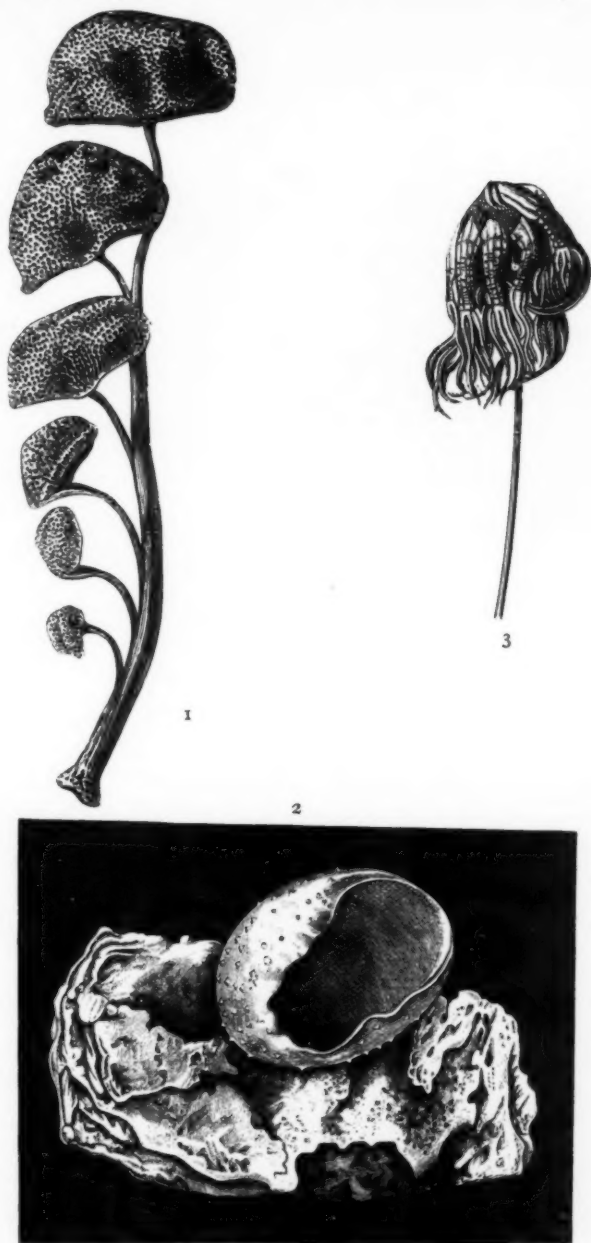




PHERONEMA CARPENTERI (THOMS.).
A Hexactinellid Sponge.







SPONGES AND COELENTERATES.

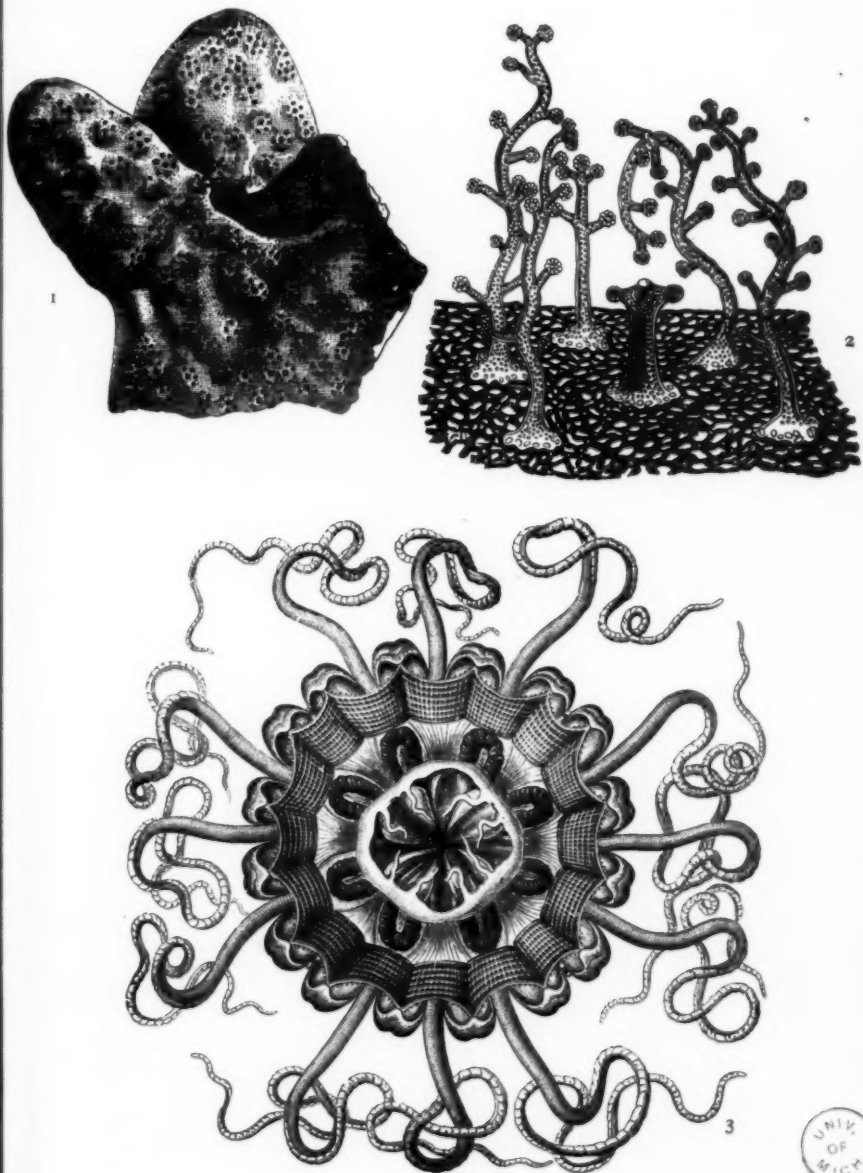
Fig. 1. *Amphilectus challengerii*, Ridley; a monaxonid; Molucca Sea; $\times \frac{1}{2}$.

Fig. 2. *Eilhardia schulzei*, Poléjaeff; a calcareous sponge.

Fig. 3. *Umbellula thomsoni*; 2,125 fms., near Madeira. The stem, 36 inches long, is cut short.







COELENTERA.

Figs. 1 and 2. *Millepora nodosa*, Esper : 1. Portion of hard skeleton, twice nat. size; 2. system of zooids expanded (the five mouthless dactylozooids bring food to the single gastrozoid in the centre).

Fig. 3. *Periphylla mirabilis*, Haeckel; New Zealand; half nat. size.



and beautiful plates remain a lasting memorial to the talents of Mr. A. T. Hollick, and it is not too much to say that they have never been excelled, though the exquisite figures in the "Novara Reise," and in Vanden Broeck's little treatise on "Les Foraminifères de la Barbade," are quite equal to them.

The specimens of *Orbitolites* were entrusted to Dr. W. B. Carpenter, and enabled him to add largely to our knowledge of the structure and distribution of the four species, one of which his report describes for the first time.

C. DAVIES SHERBORN.

RADIOLARIA.

When, in August, 1876, I attended the meeting of the British Association at Glasgow, and made the acquaintance of the naturalists of the "Challenger," the quantity and scientific value of the zoological collections there exhibited by them aroused my deepest interest. But none of the material astonished me so greatly as the wonderful Radiolarian ooze discovered by the "Challenger" in the depths of the Pacific. For I saw hundreds of microscopic preparations,

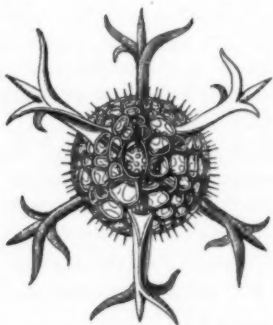


FIG. 4.—*Hexancistræ quadricuspis*, Haeckel; one of the Spumellaria. Much enlarged.

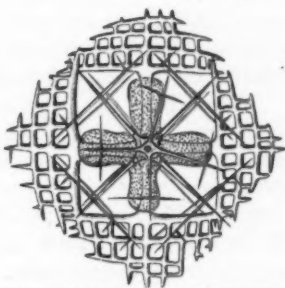


FIG. 5.—*Lithoptera darwini*, Haeckel; one of the Acantharia. Much enlarged.

each of which, in the narrow space of a square centimetre, displayed from twenty to fifty, or more, entirely new species of Radiolaria, those delicate forms of that class of siliceous-shelled Rhizopoda, of which, in my 1862 monograph, I had distinguished scarcely 200 living species. (Pl. iii., Fig. 1). Sir Wyville Thomson, who knew my work, offered me the whole collection of Radiolaria to study and report on for the "Challenger" volumes. In accepting this kind invitation, I hoped to be able to complete the work in three or four years, but the number of new and remarkable forms was so incredible, that their description occupied full ten years, and necessitated the diagnosing of over 3,500 new species. At the same time their enormous abundance as individuals in the plankton collection, proved that these minute rhizopods, quite unknown up to 1834, constituted the most important

food supply of pelagic animals. In the variety and elegance of their different shells, as well as in their morphological and phylogenetic value, they surpass all other unicellular organisms that we know. This is the more astonishing as the whole class was formerly regarded as a rare curiosity: Huxley, in 1851, had given the first accurate description of a few species of *Thalassicolla*, and Johannes Müller in his last work, in 1858, united these with the polycystines and *Acanthometra* under the name Radiolaria, having observed fifty living species. The whole number of Radiolaria described in the 2,150 pages and 140 plates of my Report, is disposed in two sub-classes, four legions, twenty orders, eighty-five families, 739 genera, and 4,318 species. This great number might easily be augmented by a diligent observer who would employ another ten years in the study of the Radiolarian ooze.

ERNST HAECKEL.

The three large volumes just referred to by Professor Haeckel are no less evidence of the industry and genius of that distinguished naturalist than of the vast field almost untouched before this expedition. It must not, however, be supposed that the cataloguing and arrangement of a great number of species is all that we owe to this section of the "Challenger" Report. There are also the details of geographical and bathymetrical distribution of the Radiolaria, and their part in the composition of deep-sea oozes: a mass of evidence bearing on the wider problems of physiography and geology.

More than this, we have gained greatly in our knowledge of the structure of the living animal. The demonstration of the complex nature of the central capsule in higher forms; of the parasitic, dark-green cells, which in one section take the place of the better-known Zooxanthellæ; of the peculiar chemical composition of the skeleton in the Phæodaria: these are all matters of the greatest interest and importance to the zoologist.

This increased knowledge of Radiolarian anatomy is especially useful as giving a basis for a new main classification into certain large groups, at once natural and convenient. Students of the older text-books—and, still more, teachers of zoological classification—will readily recognise the advantage of replacing the long lists of families usually given in such works by the two main sections, Porulosa and Osculosa; and the division of these into Spumellaria and Acantharia in the former case, and Nassellaria and Phæodaria in the latter.

A. VAUGHAN JENNINGS.

SPONGES.

As regards the Sponges, the results of the "Challenger" Expedition are of an importance which it would be difficult to over-rate. The magnificent collection of well-preserved specimens was so large and various as to require the labours of no less than six naturalists, some of them working several years, for its investigation.

The Calcareo and the Keratosa were reported on by N. Poléjaeff; the Monaxonida by S. O. Ridley and A. Dendy; the Hexactinellida by F. E. Schulze; the Tetractinellida by W. J. Sollas; and the Deep-sea Keratosa by Ernst Haeckel. In all 1,736 pages of letterpress, and 226 plates were required for the elucidation of this interesting group.

It is a subject for congratulation that the eminent naturalist, Professor Haeckel, whose work on the Radiolaria would alone have proved exhaustive to most mortals, was able to spare some of his attention for the study of a class, with which his name must ever be indissolubly connected. The inspiration of the "Kalkschwämme" was still an influence genially working in the minds of all the colleagues associated with him in the study of the "Challenger" sponges.

We are indebted to Professor Haeckel for the following account of his work on "**The Deep-sea Keratosa**":—

The twenty-six species which are comprised in this group, and which are all new, belong to eleven different genera and four families. These sponges are very remarkable by reason of their peculiar pseudo-skeleton and their symbiosis with hydroid polyps. The main mass of the body is composed either of siliceous Radiolaria shells or of calcareous Foraminifera shells. The place of an internal skeleton made by the animal itself is taken by the reticular hydrorhiza of the hydroids living in symbiosis with the sponges. Some of the larger species have the form of a broad flabelliform leaf, and their transverse diameter reaches 20 cm. or more (*Stannophyllum*); some other smaller forms (*Ammolynthus*) are simple urn-shaped utriculi, not longer than 6-12 mm., and 1-1.5 mm. broad; they are among the simplest and most primitive sponges that we know. The whole structure of these Deep-sea Keratosa is so peculiar that many experienced naturalists who had previously examined them expressed the most different opinions as to their true nature. It required a very careful study before I could confirm the view of Dr. John Murray (stated immediately after their capture) that they were undoubtedly true sponges.

ERNST HAECKEL.

When Poléjaeff commenced the study of the Calcareo, some ten years had elapsed since the publication of the "Kalkschwämme" by Haeckel, and in this interval great improvements had been introduced into the methods of section-cutting, so that a means was provided by which Poléjaeff was enabled to undertake a critical revision of the calcareous sponges, a task which, in spite of the comparatively small amount of material at his disposal, he accomplished with the most transparent success. A re-modelling of the classification of the group was one result, an exact knowledge of its anatomy and histology another.

The transition which Poléjaeff was able to demonstrate as occurring between the *Sycon* and *Rhagon* type of chamber-systems within the limits of the Calcareo is a fact of great interest, and the knowledge which we now possess of the chamber-system in this and other groups of sponges affords evidence of a strict homoplasy between the successive stages of development of this system in the

calcareous sponges on the one hand, and in the remaining sponges on the other. Nature, having presented to her the problem—how to obtain by means of flagellated cells a maximum current with minimum expenditure of energy—has solved it in two different groups of organisms in essentially the same way; and the method of solution is one which, on physical principles, appears to be inevitable.

The number of species of *Calcarea*, all described from "Challenger" material, is thirty, of which twenty-three were new; they are grouped in twelve genera, of which four were new. (Pl. vi., Fig. 2.)

Poléjaeff's work on the *Keratosa* contains a large amount of exact information on the anatomy and histology of these sponges, but the material at his command was in this case too limited to afford sufficient data for a satisfactory system of classification: indeed, to arrive at this, a study of the *Keratosa* alone is inadequate, they must be taken in connection with the *Monaxonida*, from which the majority of them have almost certainly been derived.

Thirty-four species of *Keratosa* were obtained by the "Challenger," of which twenty-one proved to be new; they are distributed among twelve genera, none new.

It is to the *Hexactinellida* that the greatest interest naturally attaches. The exquisite beauty of such forms as Venus' Flower-Basket, the marvellous symmetry of complicated spicules which many well-known members of the group afford to the microscope, and the long acquaintance which the palæontologist has had with these sponges in the fossil state previous to their revelation as living forms by the dredge, have rendered them remarkable in popular esteem. Till, however, Schulze undertook their investigation, they were still objects of mystery, for nothing was known of the structure of the sponge itself. It was a great opportunity when the "Challenger" collection was placed in Schulze's hands, and splendidly he employed it. By means of the microtome all the well-preserved specimens were laid open to precise observation, and on the exact knowledge of structure thus obtained was based the foundation of a natural system of classification. The arrangement of the soft parts and the character of the chamber-system were found to be singularly uniform; in the latter a syconate character prevailed and indicated the position of the *Hexactinellida* as the lowest of the siliceous sponges, a fact in harmony with their very early appearance in the stratified series of the earth's crust. The uniformity of the chamber-system and the persistence of a sexradiate form in the spicules, sharply mark off the *Hexactinellida* from all other siliceous sponges; they form a truly natural order—an enviable position amongst sponges, to which the *Calcarea* alone among the rest have like claim.

If the canal-system is uniform and thus of no use for classificatory purposes within the group, the spicules are just the reverse, and by their extreme diversity offer characters of the highest taxonomic

importance. It is noteworthy that it is not so much the large as the minute spicules which were found to possess most significance in classification, and this is true not alone of the Hexactinellida, for Ridley and Dendy found it to hold good in the case of the Monaxonida, and Sollas in that of the Tetractinellida.

Schulze did not confine his studies to the material obtained by the "Challenger," but extended them to embrace all known material, so that the report on the Hexactinellida is at the same time a veritable monograph. The number of species obtained by the "Challenger" was ninety, of additional species thirty-six; of new species sixty-nine were described, of previously known forty-six, they were arranged in fifty genera, of which twenty-two were new. (Pl. v.)

Ridley and Dendy in their elaborate report on the **Monaxonida** describe 213 species of which 158 are new, and arrange them in fifty-four genera, of which five are new. They modify and improve existing classifications, and point out that the deep-sea members of the group are usually distinguished by a greater degree of symmetry than those which inhabit shallower waters. (Pl. vi., Fig. 1.)

The **Tetractinellida**, including the stony sponges (Lithistids) share some of the interest which attaches to the Hexactinellida, with which in the early days of spongology they were sometimes confused. Great use was made of the microtome in their investigation, every species being examined in thin slices: in contrast to the Hexactinellids the characters of the soft parts were found to differ considerably in different groups, and thus to furnish useful aid in classification. The chamber-system was found never to fall to the level of the syconate type, it is always rhagose, and presents two very different degrees of complexity, the simpler or eurypylous, and the more complex or aphodal. It is in the Tetractinellida that the sponges seem to culminate, some of their members attaining a degree of specialisation unknown in other groups.

In addition to the specimens brought home by the "Challenger," all previously described material was made a subject of study, and the results embodied in the Report. Of species obtained by the "Challenger," there were eighty-seven, of which seventy-three were new; they were arranged in thirty-eight genera, of which eighteen were new. Of additional species 221 were described, and of additional genera forty-five, of which fifteen were new.

The important question of distribution was fully considered in all the reports, the facts were tabulated, and in most cases subjected to very elaborate analysis.

During the preparation of the reports, advantage was taken of the fact that so many observers were simultaneously engaged in the study of sponges, to discuss together a scheme for the simplification of the nomenclature of spicular forms. Assistance was afforded by Stewart, von Lendenfeld, and Vosmaer in this work, and a consistent system proposed, which has since found very general adoption. In

this system the distinction between axis and actine, first pointed out by Sollas, played a considerable part.

The outcome of the Expedition, in the case of the Sponges, was, briefly put, to reveal to us the existence of a vast number of previously unknown forms, some of them of extreme interest, to extend our knowledge of anatomy and histology throughout the group, to render more natural our systems of classification, and to lay the foundations of a knowledge of distribution, both geographical and bathymetrical. No doubt there remains plenty of room for addition and modification, but the more immediate need, in the study of sponges, is for further knowledge of their embryology, and still more of their comparative physiology.

W. J. SOLLAS.

COELENTERA.

Perhaps one of the most striking results of the "Challenger" Expedition, so far as the coelenterates are concerned, was the overthrow of the old group of the **Tabulata**. Doubt had, it is true, been already thrown upon the value of the tabulæ in corals as a character for classification by the discovery made by Nelson and Agassiz that the Milleporidæ are hydroid and not anthozoan corals. During the cruise of the "Challenger," Moseley was able to confirm this result, and to give a first-rate description of the dimorphism occurring in the family. The drawing which Moseley gave of the expanded polypes of *Millepora* has been copied into nearly all the standard works of zoology (Pl. vii., Figs. 1, 2). But Moseley was able to extend this discovery, and prove that all the genera belonging to the family Stylasteridæ are truly hydrocorallines. The volume of the "Challenger" Report which deals with this family is perhaps more full of valuable original results than any in the whole series. No memoir that has been published before or since contains so accurate and so detailed an account of the anatomy of any group of corals. It is, and will remain for many years to come, the only standard work on this family.

A great deal more might be written upon this result alone of Moseley's work, but reference must be made to the striking and unexpected discovery that the Tabulate coral *Heliopora* was not a Zoantharian, but an Alcyonarian. The relations of this genus to several fossil forms, such as *Syringopora*, *Favosites*, *Halysites*, etc., were pointed out by Moseley, and the result of his investigations and suggestions has been the final abandonment of the Tabulata as a natural group.

Another important investigation of Moseley's, made during the cruise of the "Challenger," and published in the *Results*, was the description of the anatomy of the interesting reef alcyonarian *Sarcophyton*, and the discovery of a dimorphism of the polypes in this genus similar in some respects to that which was known to occur in

the Pennatulids. Moseley introduced in this memoir the terms "autozooids" and "siphonozooids" in place of "polypes" and "zooids," the words used by Kölliker for the tentaculate and non-tentaculate forms respectively, and these terms have since been used almost exclusively by writers on the anatomy of Alcyonaria.

S. J. HICKSON.

In the special reports on the **Alcyonaria**, the Orders of the Alcyonacea and Gorgonacea were examined by Professors E. Perceval Wright and Th. Studer; that of the Pennatulacea by Professor A. Kölliker. Of the **Pennatulacea** thirty-eight species belonging to nineteen genera were found, amongst which seven genera and twenty-seven species were new to science; unfortunately most of the species were represented by but one or two specimens. With regard to the geographical distribution of this group, the new forms were of great interest, both extending and confirming the conclusions previously arrived at by Kölliker in his well-known Monograph (1872). As to their horizontal distribution, Kölliker thinks it proved that they are not distributed over all seas in a regular manner; taking the families, he shows that they seem to have fairly well defined centres from which they spread more or less widely; perhaps the distribution of the Umbellulidæ is the most remarkable. Known for over a century from only one locality, near the coast of Greenland, forms of it were found during the cruise between Portugal and Madeira, in the Atlantic under the Equator, west of Kerguelen Island, in the South Polar Sea, off the coasts of New Guinea and of Japan, and from the middle of the North Pacific Ocean. The knowledge of the vertical distribution of the group was greatly increased: when Kölliker published his Monograph he was justified in saying that the great majority of the species were shallow-water forms; but now the deep-sea forms are about as numerous as those living near shore; *Umbellula thomsoni*, Köll. (Pl. vi., Fig. 3), was found at a depth of 2,125 fathoms, and *U. leptocaulis*, Köll., at 2,440 fathoms, while several other species were found at depths exceeding 1,000 fathoms.

Among the **Alcyonacea**, owing to their being for the most part shallow-water forms, the species found were not very numerous, but some extremely interesting additions were made to the Siphonogorginæ, a group only described by Kölliker in 1874. The researches of Moseley on *Heliopora coerulea* and *Sarcophyton lobatum*, have already received due appreciation from Professor Hickson. The species of the genus *Spongodes* collected numbered twenty-two, of which eighteen were new; four new species of *Siphonogorgia* are described, while the new genera *Paranephthya*, *Scleronephthya* and *Chironephthya* are established for forms nearly related to this genus of Kölliker.

Perhaps the more remarkable species occurred among the **Gorgonacea**, an immense number of new genera and species being

described, of which only the most remarkable can be referred to. *Callozostron mirabilis* was taken from a depth of 1,675 feet, and at the most southerly point attained during the cruise; the mass has the appearance of a large annelid worm, over three-fourths of the surface of which the beautiful primnoid polypes are attached; several species of the genera *Strophogorgia* and *Dasygorgia* are described. Numerous additions are made to the Isidæ, and one *Bathygorgia profunda* was dredged from a depth of 2,300 fathoms between Yokohama and the Sandwich Islands. Many new species of the genera *Stenella* and *Thouarella* were found. *Primnoides sertularioides* dredged off Prince Edward Island constitutes a peculiar type among the Primnoidæ. Several new genera of Muriceidæ, with numerous species, were found among the Gorgonidæ: two merit particular mention, *Platycaulos danielsseni* from shallow water at Banda, and *Callistephanus koreni* from a depth of 420 fathoms off the Island of Ascension. The genus *Scirpearrella* is made for four new species from the Pacific. Among the Briareidæ, *Keroeides koreni*, is described as a new genus and species from Japan. Among the Melitodidæ many new species of *Melitodes* and *Parisis* are described.

From even such a hasty glance at the general results of these reports it will be seen that most important contributions to our knowledge of the structure and affinities of the Alcyonaria were made by Moseley, while our knowledge of the existing species has been extensively added to.

E. PERCEVAL WRIGHT.

The **Antipatharia** collected by the "Challenger" were fairly numerous, and formed the subject of a really brilliant memoir by the late George Brook. Before the appearance of this volume, the zoology of this group of zoantharians was in hopeless tangle, and it was practically impossible to obtain a satisfactory determination of any common species. Brook succeeded admirably in putting the group in order, and his monograph will doubtless serve as the standard work of reference for many years to come. But, apart from the value of this report to the systematic zoologist, the interest of the purely morphological results is undoubtedly very great. The occurrence of an interesting form of dimorphism in certain genera, and the presence of branched retractile tentacles in the new genus *Dendrobrachia* (the type of a new family), are two of the most important points which Brook's brilliant monograph described for the first time.

S. J. HICKSON.

The **Actiniaria**.—As the brothers Hertwig, in the first of their "Studies on the Theory of Germinal Layers," had written an exhaustive treatise upon the structure of sea-anemones, it was natural that the "Challenger" material should go to one of them. The report was published in vol. vi., but a supplement appeared in

vol. xxvi. As the beautiful Naples monograph of Andres appeared before the supplement was written, R. Hertwig had the opportunity to discuss the scheme of classification and the systematic criteria adopted by that naturalist, and to suggest a scheme of classification of the whole group that later research has done little to modify.

Undoubtedly the most interesting individual anemones obtained by the "Challenger," were the forms called *Corallimorphidæ* by Moseley. In these, several features, usually present in anemones, are replaced by features more characteristic of corals. The tentacles are arranged in radial rows, so that several of them open into the same radial cavity; the disk is stiff and leathery, and has no sphincter muscle by which it may be drawn up like a bag closed by a string over the retracted tentacles; the nematocysts are peculiarly large. From examination of these and of some other peculiar forms, Hertwig reached the conclusion that the old distinction between the corals or sclerodermatous anemones, and the soft-skinned, or true anemones, is not morphological, and he inferred that as knowledge of the soft parts of the Sclerodermata is obtained they will gradually be distributed among the different groups of anemones.

The anemones he divided into six main groups, well-marked off by important structural features. These are the *Edwardsiæ*, *Cerianthæ*, *Zoantheæ*, *Paractiniæ*, *Monauleæ*, and *Hexactiniæ*. The last group contains by far the largest number of forms.

In the hexactinians there is a great dichotomy between those like the *Corallimorphidæ*, with double or multiple wreaths of tentacles, and those in which the tentacles form a single wreath. The former group is the less known, and to it probably belong a number of the stinging anemones of tropical seas, the anatomy of which is imperfectly known. Hertwig showed that the old distinction between anemones with retractile, and anemones with non-retractile tentacles, should be replaced by distinctions based on the presence or absence and the character of the sphincter muscle.

The material at Hertwig's disposal was neither large enough nor sufficiently well-preserved to complete the working out of the group, but there is no question but that he has laid the foundation for future investigation. With his reports and the monograph of Andres, which however, deals chiefly with external characters, those who have an opportunity of studying actinians will find the way prepared for most interesting and valuable investigations.

P. CHALMERS MITCHELL.

In the group of the *Hydroidea* no very important results were obtained. A few interesting new genera were found, and some remarkable points in geographical distribution referred to; but the collection was not a large one, and the results obtained from its examination present no features of special interest. The *Hydro-medusæ* and *Scyphomedusæ*, however, were the occasion of very

beautiful reports from the pen and pencil of Professor Haeckel, to whom we are once more indebted for the following note :—

The report on the **Deep-Sea Medusæ** describes and figures (in thirty-two plates) only eighteen new forms, and among these about one-half may not be true inhabitants of the deep sea, but captured accidentally during the hauling in of the net. But of the other half, a part are certainly true deep-sea Medusæ, characterised by a quite peculiar organisation, viz., among the Craspedotæ (or Hydromedusæ), the Pertyllidæ; and among the Acraspedæ (or Scyphomedusæ), the Periphyllidæ (Pl. vii., Fig. 3), and the Atollidæ. As a general introduction to this report is given a short sketch of the comparative morphology of the Medusæ, based upon investigations of these beautiful Plankton-animals which I had carried on for twenty-five years.

The report on the **Siphonophoræ**, with its fifty plates, forms a complete though short monograph. Since in my numerous voyages during thirty years I had paid special attention to these most interesting pelagic Hydrozoa, I was prepared to elaborate the materials of the "Challenger," of which no naturalist to the Expedition had made a special study. Combining the results of this examination with my own observations made on living animals, I was able to fill up the numerous gaps between the older descriptions, to elucidate many errors, and to give a more complete and consistent idea of the whole organisation than was formerly possible. Among the new Siphonophoræ discovered by the "Challenger," special interest attaches to the Aurnectidæ (with the two families Stephanidæ and Rhodalidæ), which constitute a new order of this class, adapted to deep-sea life in a very remarkable manner.

ERNST HAECKEL.

ECHINODERMA.

Crinoidea.—In connection with the "Challenger" Expedition the Stalked Crinoids have a special importance. For it was the discovery of *Rhizocrinus*, in 1864, by G. O. Sars, and its great interest as resembling extinct forms, which, through the intervention of Dr. W. B. Carpenter and Sir Wyville Thomson, led to the cruise of H.M.S. "Lightning," in 1868. The results of this cruise, notably among Echinoderma, were so remarkable, that it was immediately followed by the expeditions of the "Porcupine," and eventually by the great voyage we now commemorate. It was, moreover, these animals which the original head of the scientific staff wished to take under his particular care, regarding them as "the most remarkable of all the deep-sea groups, both on account of their extreme rarity and of the special interest of their palæontological relations." Formerly regarded as a group "on the verge of extinction," and as pre-eminently abyssal, the Stalked Crinoids have been proved by the dredge of the "Challenger" (nor must we forget that of the U.S.C.S. "Blake"), to be as widely distributed in depth as almost any other group (50 to 3,200 fathoms), while their numbers, in individuals if not in species, show scarcely any decrease from those of Jurassic and Cretaceous seas. Before 1869 only three genera, including five species, of Stalked Crinoids were known. The "Porcupine" added

one genus and three species, and the "Challenger" added two genera and twenty species, which, with a species from the "Blake," brought the number up to the six genera and twenty-eight species discussed in P. H. Carpenter's Report.

If present seas compare unfavourably with those of Palæozoic periods in the number of species of Stalked Crinoids, they at least rival them when the Unstalked Crinoids are taken into account. Carpenter's second volume considers six genera collected by the "Challenger," of which two were new, and 180 species, of which 110, including 88 new forms, were dredged by the "Challenger." A less conscientious or less learned worker would have vastly increased the number; Carpenter himself at first estimated them as over 400.

The new genera discovered were of profound interest. Among stalked forms: *Bathycrinus* (Pl. viii., Fig. 1), with fused basals and remarkable arrangement of axial nerves; *Hyocrinus* (Pl. viii., Fig. 2), singularly archaic in its lofty basals and massive orals, and somewhat resembling certain Silurian crinoids in its lengthy pinnules; *Metacrinus*, with more brachials below the first main axillary than had been seen for many a geological period. Among unstalked forms: *Promachocrinus* (Pl. viii., Fig. 3) with twice as many radials as we were used to; *Thaumatoocrinus* (Pl. viii., Fig. 4), that wonderful creature from the

Southern Ocean, reminiscent of the Taxocrinidæ in its anal process (*aa*), of the Rhodocrinidæ in its interradials (*i*), and of the Larviformia in its orals, yet all the time with a centrodorsal (*cd*) like any *Antedon*.¹

In distribution we note how the widest range, both geographical and bathymetrical, is possessed by those forms that we have reason to regard as geologically older or morphologically simpler, though so far as present knowledge goes, it does not appear that a wide range in depth is always correlated with wide horizontal distribution.

Such increase to our knowledge would have resulted from the voyage of the "Challenger," to whomsoever the collections had been entrusted. But the studies of Carpenter revealed to us far more. It was not in the region of histology that much was gleaned, for the specimens had unfortunately not been preserved to that end, and had moreover been many years in spirit before they reached

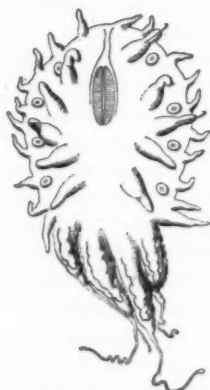


FIG. 6.—*Myzostoma quadri-fulum*; parasitic on *Antedon bidentata*; from ventral surface; $\times 4$ diam.

¹ Mention may here be made of the parasites of the crinoids, *Myzostoma* and *Stelechopus*, which have induced the formation of plated swellings on the exterior of recent and fossil forms. Von Graff, by his study of the "Challenger" specimens, threw great light on the structure and affinities of this obscure group, which the discovery of a setiferous larva now causes us to place among the Chætopoda. (Fig. 6.)

Carpenter. It was, first, in the enlightened comparison with extinct crinoids, in the elucidation of many palæontological problems, and in the true explanation of what to some might seem morphological anomalies. Secondly, it was in the foundation of an exact terminology, and the establishment of true systematic characters: the multitude of unstalked crinoids, which might have confused a less patient worker, enabled Carpenter to formulate certain laws with regard to the branching of the arms and the mode of union of the brachials, to adapt and improve the ingenious method of formulation employed by Bell, and finally, to sort the various species into ten groups for *Antedon* and eight for *Actinometra*, which have been of the greatest assistance to subsequent workers. Each fresh step that I take into the depths of my own ignorance enables me the better to appreciate the learning of my dead friend, and as I rise once more from the perusal of these magnificent volumes I feel that not the least result of the "Challenger" Expedition was the field it afforded to Herbert Carpenter for the exercise of his marvellous industry and clear insight.

The **Echinoidea**, though still abundant in both individuals, species, and genera, are, like the crinoids, of great palæontological importance, and it is fortunate that they, too, were placed in the hands of a zoologist who could illumine the study of both recent and fossil forms by his own knowledge in both departments.

When Professor Alexander Agassiz wrote his report, 297 recent species were known, of which forty-nine were due to the "Challenger." One-third of these species had been discovered since deep-sea dredging began, to which third the "Challenger" contributed more than a half, also adding fifteen new genera. Moreover, seven genera, previously known only from fossils, were found in the deep sea. In his "Revision of the Echini," Agassiz had subdivided the recent faunæ of sea-urchins into six realms—Atlantic, Circumpolar, Australian, Antarctic, Pacific, and American. The knowledge of distribution gained by the "Challenger" caused these subdivisions to lose some of their significance, but enhanced the importance of the bathymetrical zones, especially the Littoral, Continental, and Abyssal regions, on which Agassiz had already laid stress. It is not, however, the pressure varying with depth that appears the important factor, but rather the gradual spreading of life from the shore to the abyss; and so we find that those genera which extend from the Littoral to the Abyssal region are those which date back to the Cretaceous period, that those with more restricted range are not older than the Tertiary, while those which extend only slightly beyond the Littoral range are found only in the more recent Tertiary periods. A similar result was seen to follow in the crinoids. In the Littoral region temperature has some influence in separating the diverse faunæ, not, however, by its highest, but by its lowest limits.

The knowledge gained from the deep-sea forms has also caused

some changes in the classification of the urchins. Though Agassiz retains the Palechinoidea as a sub-order, he points out that it can no longer be contrasted with all other types of Echinoidea. Carpenter in his reports, it will be remembered, emphasised the distinction between Palæocrinoids and Neocrinoids; and in that case it was reserved for palæontologists to show that such a division could not be maintained.

Most important among deep-sea urchins is the elongate *Pourtalesia* (Pl. ix., Fig. 3), first found by Count Pourtalès between Key West and Havana, and the subject of Lovén's classical study. To the family containing this and other strange shapes, twelve new species were added by the "Challenger." "It was" says Dr. J. W. Gregory, "the close resemblance of some of these to the Cretaceous Ananchytidæ that led to the well-known and oft refuted generalisation that we are still living in the age of the Chalk." Among these the genus *Cystechinus* with its thin flexible test (Pl. ix., Fig. 2) is of special interest, as presenting in the structure of its plates a surprising similarity to such Palæozoic fossils as *Palæechinus*: this genus was not a known fossil till Gregory described *Cystechinus crassus* from the Pliocene bed of Barbados. Here also are placed the slipper-shaped *Echinocrepis*, and the *Galerites*-like *Urechinus*. These and other deep-sea Spatangoids resemble the fossil, but differ from nearly all other recent Spatangoids, in the absence or slight development of the fascioles. "Interesting from an embryological point of view," says Agassiz, "are such novel and strange forms as *Aërope* (Pl. ix., Fig. 1) and *Aceste*, which have assumed a facies absolutely identical with that passed through by the young of the *Brissina* of to-day. In these two genera the odd anterior ambulacrum is immensely developed, its suckers are of a gigantic size, entirely out of proportion to the rudimentary ones of the paired ambulacra."

It was the dredgers on the "Porcupine" who were the first to be startled by the worm-like movements of the living Echinothuridæ, urchins whose flexible tests with imbricating plates were already known as Chalk fossils. To our knowledge of this family much was added by the "Challenger." The young of the group and such species as *Asthenosoma gracile*, *Phormosoma asterias*, and *P. rigidum* show that the lapping of the plates and the distinction between the actinal and abactinal surfaces are features of gradual development, and render it difficult to separate this family from the Diadematidæ. Some species of the family present peculiar modifications of the spines. Sometimes baggy envelopes with an irritating fluid surround the sharp spines, and add a numbing effect to their painful wounds. Sometimes the spines end in knobs or in broad conical shoes, as in *Phormosoma hoplacantha*; these serve as pattens to raise the animal from the ground. The Arbaciadæ have a similar cap on their spines, and in *Coelopleurus* it was shown by "Challenger" specimens to be developed to four or five times the length of the spine proper. It is

suggested by Agassiz that "the immense triangular and curved spines thus formed served to raise the test, as it were on stilts, and enabled the sea-urchin to move with considerable rapidity."

Among other interesting discoveries may be mentioned *Porocidaris elegans*, with its curved actinal spines and its long, smooth, primary spines; and *Salenia hastigera*, the fourth recent species of a genus well known in the Jurassic and Cretaceous rocks, and always held of great morphological importance owing to the large size of the plates in its apical system.

F. A. BATHER.

The collection of **Asteroidea** has been stated to be one of the most important made during the voyage of the "Challenger"; it was unquestionably the most important contribution to this group of animals that had ever been made. Representatives were obtained of more than three-fourths (77.5 per cent.) of the previously known types of starfishes; and, in addition to these, the collection contained 184 new species and twelve new varieties, which furnished the types of thirty-four new genera and four new sub-genera (five of the genera and two sub-genera being, however, based on types of which one or more representatives had been previously known).

The special interest of the collection may be said to centre in the large number of forms obtained from the Abyssal zone, which has practically opened a new chapter in the history of the Asteroidea. The archaic characters of many of these are highly remarkable, and throw important light not only on the relationship of numerous existing forms and upon the classification of the group as a whole, but upon the systematic position of many of the extinct members of the class.

One hundred and nine species and varieties were obtained from the Abyssal zone (*i.e.*, from depths greater than 500 fathoms), all except four of which were discovered by the "Challenger." These represented thirty-five genera, all but sixteen of which were discovered by the "Challenger." Twenty-six genera of starfishes were found living in depths greater than 1,000 fathoms, and all but eight of these were discovered by the "Challenger."

The Abyssal zone has furnished the following new genera:—*Pararchaster*, *Dytaster*, *Lonchotaster*, and *Aphroditaster*, in the Archasteridæ. *Porcellanaster*, *Styracaster*, *Hyphalaster*, and *Thoracaster*, constituting the Porcellanasteridæ, a family wholly due to the "Challenger." *Phoxaster*, in the Astropectinidæ. *Chitonaster*, *Nymphaster*, and *Paragonaster*, in the Pentagonasteridæ. *Cnemidaster*, in the Zoroasteridæ, and *Neomorphaster*, in the Stichasteridæ. *Marsipaster*, *Benthaster*, and *Pythonaster*, in the Pterasteridæ—the latter being, perhaps, one of the most remarkable types obtained during the expedition (Pl. x., Fig. 2). To the Brisingidæ the "Challenger" added a number of species, together with the new genus *Colpaster*.

By the discovery of this large series of forms, living under

conditions of comparative isolation in abyssal depths, much light has been thrown upon the range and character of the morphological plasticity of many genera, as well as upon the probable archaic characters of a number of forms previously known only from shallow water.

Several novel points of structure are met with among deep-dwelling Asterids; but mention can only be made here of two or three. For instance, the Porcellanasteridæ, in addition to their archaic form, are remarkable for the presence of "cribriform organs,"—peculiar structures associated with the marginal plates, which probably serve as percolators (Pl. x., Fig. 3). Many of the members of this family possess a more or less elongate, epiproctal, tubular prolongation; and "segmental pits and papillæ"—organs whose functions are as yet unknown—occur in some forms.

The Pterasteridæ, which are now found to possess a world-wide distribution in deep water, are remarkable for the dorsal nidamental chamber in which the young are kept for a period, as in a marsupium (Pl. x., Fig. 1). Direct development is thus fostered, and the intervention of a locomotory pseudembryo avoided. A number of other Asterids belonging to different families have been discovered, in which the same result is attained by different means, and not only in star-fishes but in other groups of the Echinodermata, *e.g.*, Holothuroidea, Echinoidea (see *Hemiasiter cavernosus*, Pl. ix., Fig. 4), Ophiuroidea. The prevalence of forms in southern latitudes presenting this mode of development has been noticed as remarkable; it is probable, however, that it will be found on further research to be more widely distributed than has hitherto been suspected.

The abyssal Asterid-fauna brought to light by the "Challenger" is not the only interesting part of the collection. Many valuable additions have also been made to the fauna of the Littoral and Continental zones; and some of these increase our knowledge of the relationship of previously known deep-water forms, and add greatly to the solidarity of the group. Under this category may be mentioned the new genus, *Pholidaster*, which is perhaps the shallow-water representative of *Zoroaster*; and the interesting *Peribolaster*, which in like manner recalls, and is structurally related to, the abyssal *Korethraster*. *Pseudarchaster* is an interesting annectant genus between the Archasteridæ and Pentagonasteridæ; and not less important are the genera *Leptogonaster*, *Tarsaster*, *Rhipidaster*, *Pervnaster*, and a large number of specific forms belonging to genera previously known.

It is needless to say that the knowledge of the geographical distribution of types has been largely extended.

W. PERCY SLADEN.

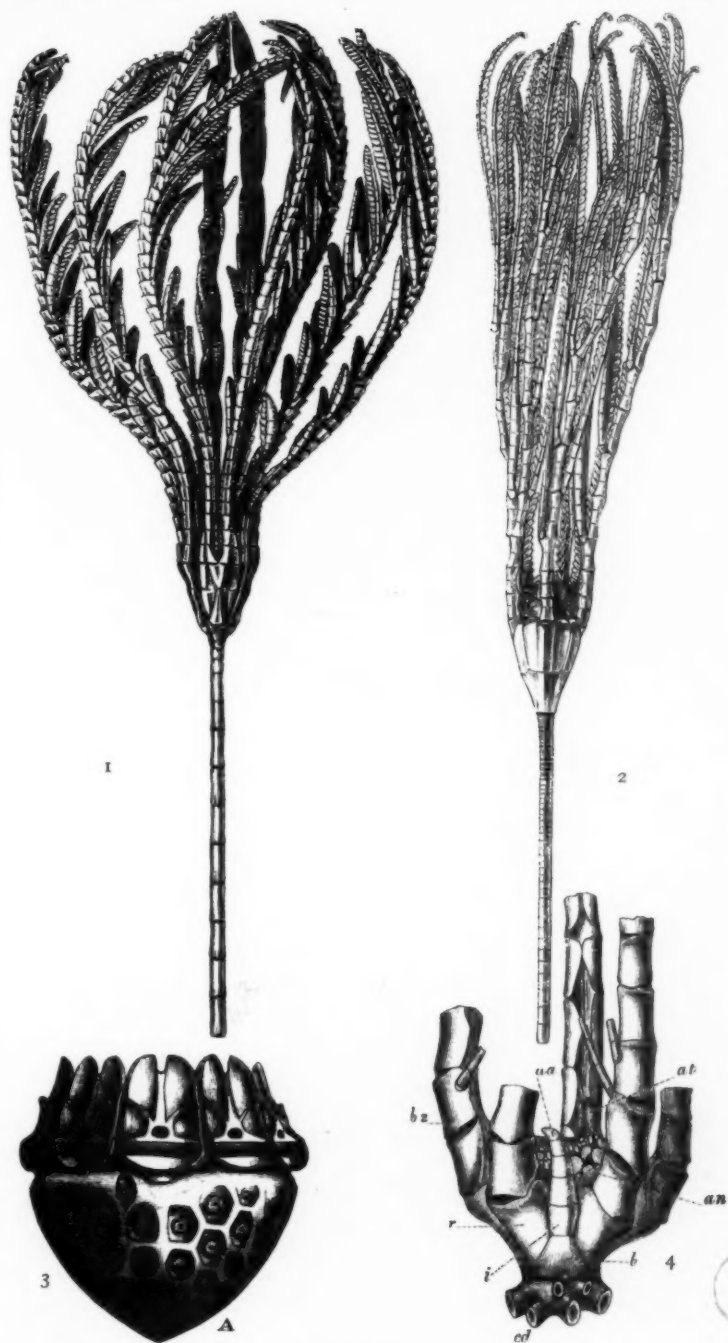
No better account of the Ophiuroidea collected by the "Challenger" can be desired than that furnished to the *Narrative* by Mr. Theodore Lyman, after the completion of his Report:—

"In no group, perhaps, was our knowledge more extended by the explorations of the "Challenger" than in that of the Ophiuroidea. The number of known living species was increased from 380 to about 550, or nearly by one half, while the corresponding increase of novel groups is indicated by the addition of twenty genera. By far the greater number of new species are of the deep-sea fauna; that is to say, they occur below the 100 fathom line, so that this Expedition has furnished the first opportunity of comparing the littoral and the deep faunæ over a wide extent of the oceans of the world. The result is that these Echinoderms are found to be animals which live very much in defiance of temperature, light, and water pressure. Something other than environment has determined their growth; or rather, their growth is not affected by an important part of their environment. To be sure there are some genera which are confined to the profound region of cold, darkness, and crushing weight; such are *Ophiotrochus*, *Ophioplinthus*, and *Ophiernus*; but there are others, for example *Amphiura* and *Ophiacantha*, which are found from the littoral zone down to the lowest points reached by the dredge. In the different zones these genera may present modifications; for instance, the *Amphiura*, below 1,000 fathoms, often have more numerous mouth papillæ, and the corresponding *Ophioglypha* usually have swollen arm-plates and a microscopically tuberculous surface. Such structural features, however, plainly have no connection with the conditions of life, nor have they any relation to the survival of specially favoured forms. From a depth of over 1,500 fathoms are found the strongly armoured *Ophiomusium pulchellum* (Pl. xi., fig. 2), the delicate *Amphilepis*, and the *Ophiomitra chelys* (Pl. xi., fig. 1), with its thorny spines and soft disk. At that great depth the peculiar conditions, apparently so unfavourable to a rich and varied growth, have not checked the development of widely differing forms.

"While, however, the Ophiuroidea yield little to the dictation of light, heat, or water pressure, they show well-marked laws of growth. Certain genera take the lead, like the larger clans of a barbarous nation. The collections of the 'Challenger,' when combined with those of the 'Blake,' show that the four genera *Ophioglypha*, *Amphiura*, *Ophiacantha*, and *Ophiothrix* contain more than two-fifths of the known species. There is a tendency also to elaboration and variety in structure. The naked and embryonic genera, like *Ophiomyxa* and *Ophiogeron*, have few representatives; while the finely constructed *Ophioglypha* has many species, and even the highest group, composed of the closely allied *Ophiura*, *Pectinura*, and *Ophiopora*, is pretty strong in numbers.

"The dredgings of the 'Challenger' have further taught us that we must not look exclusively in the abysses for surprising shapes, or for those that connect us closely with geological times. If the singular *Ophiolithia* must be sought in 1,800 fathoms, its relative *Ophiolithus* may be found in less than 100 fathoms; and if *Ophiomastus* from the deep sea brings to mind the extinct *Aspidura*, *Pectinura* of the littoral zone recalls the so-called *Ophiura* of the Oolite. Nor must we forget that the extraordinary *Astrophiura*, apparently intermediate between the Brittlestars and Starfishes, lives in shallow water."

Before the "Challenger" Expedition our knowledge of the **Holothurians** was limited almost exclusively to littoral forms. By the Expedition our acquaintance with these was greatly increased, and an entirely novel fauna of the abyss discovered. The deep-sea



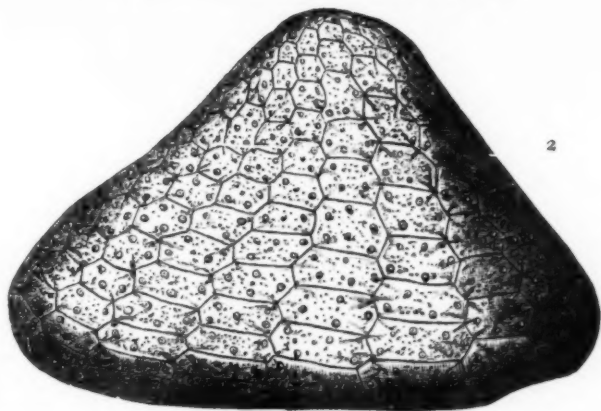
CRINOIDEA.

- Fig. 1. *Bathycrinus campbellianus*, P.H.C.; mid-Atlantic, 1,850 fms.; $\times 3$.
 Fig. 2. *Hyocrinus bethellianus*, Thoms.; Southern Ocean, 1,600 fms.; $\times 2$.
 Fig. 3. *Promachocrinus kerguelensis*, P.H.C.; centrodorsal and radials.
 Fig. 4. *Thaumatoocrinus renovatus*, P.H.C.; from anal side; arms and cirri broken off.





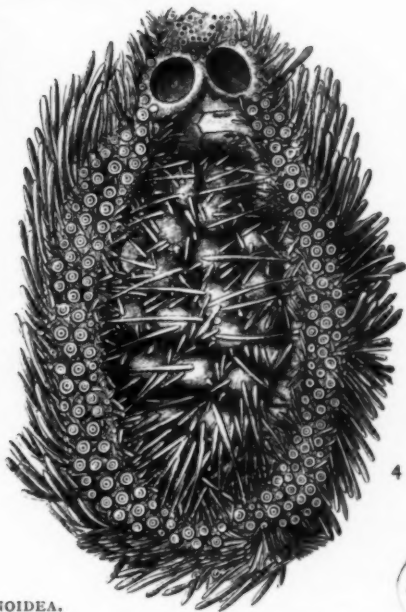
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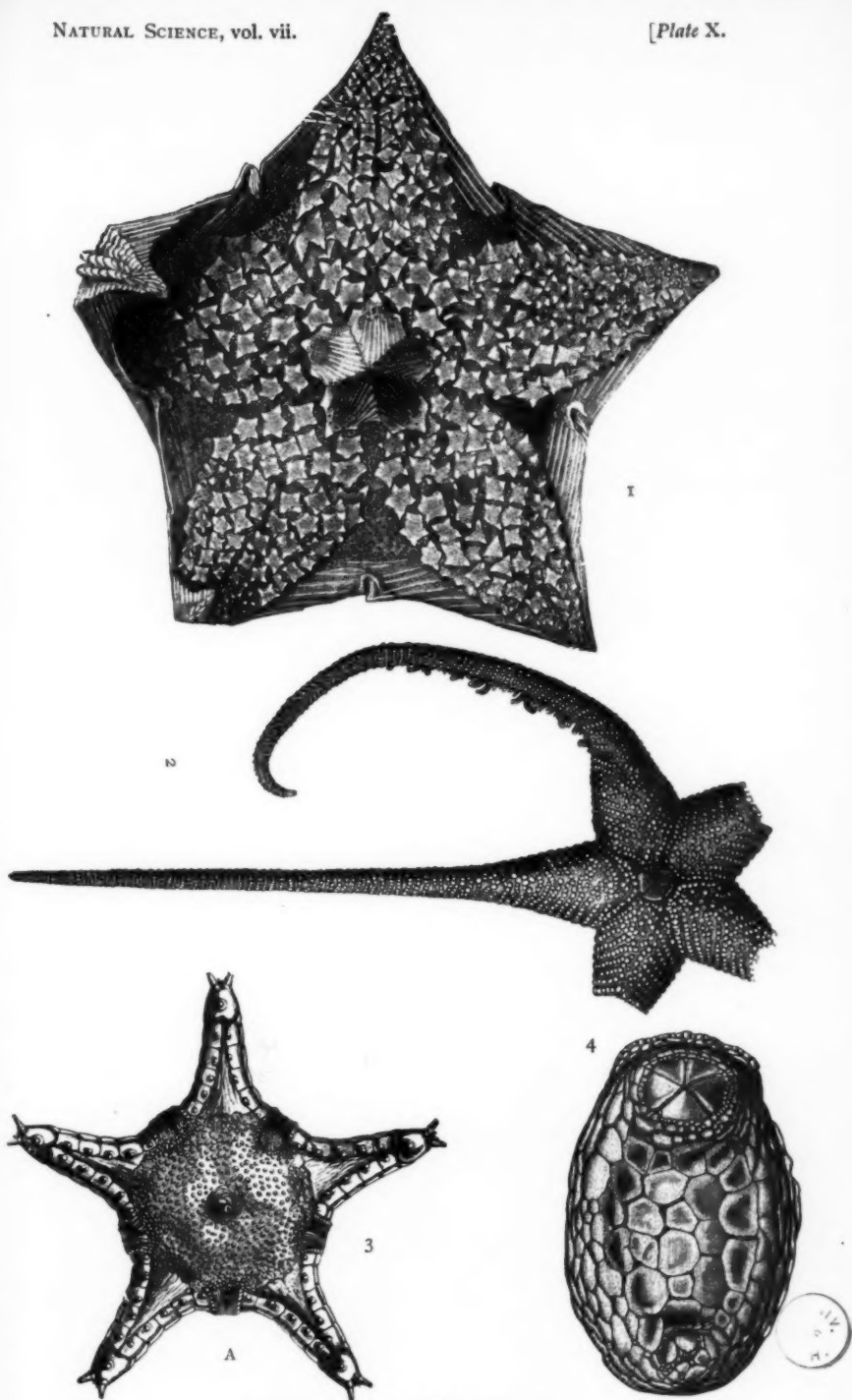
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ECHINOIDEA.

Fig. 1. *Aërope rostrata*, Thoms. Fig. 2. *Cystechinus wyvillei*, A. Ag.; spines removed. Fig. 3. *Pourtalesia ceratopyga*, A. Ag.; the abactinal surface, covered with spines. All nat. size. Fig. 4. *Hemiaster cavernosus* (Phil.); one of the marsupial recesses, with eggs inside. $\times 5$.



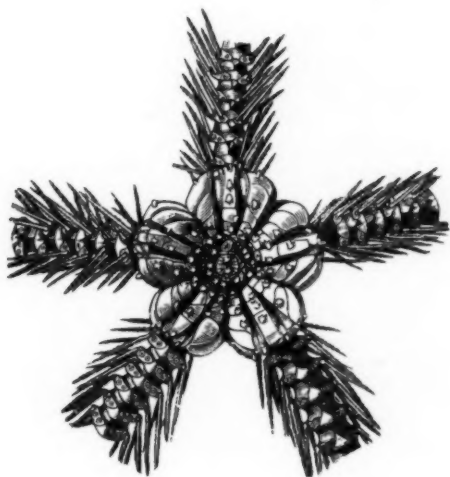




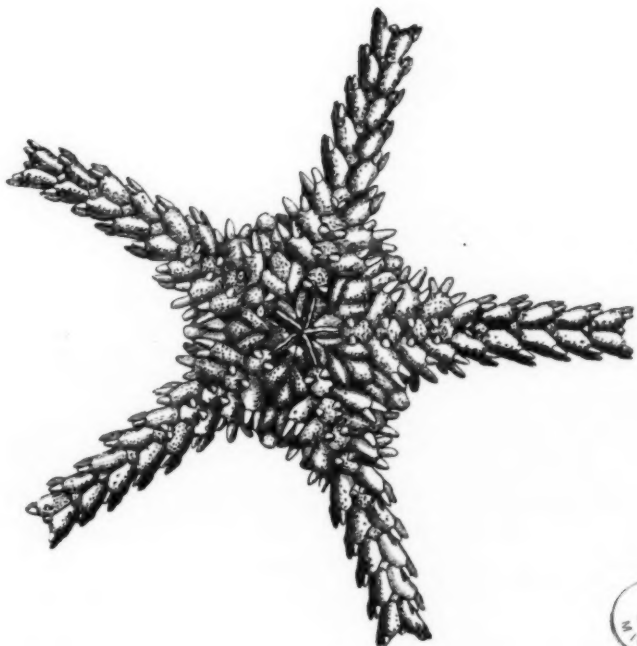
ASTEROIDEA AND A HOLOTHURIAN.

Fig. 1. *Hymenaster sacculatus*, Sladen; abactinal aspect, with marsupial tent in centre; slightly enlarged. Fig. 2. *Pythonaster murrayi*, Sladen; abactinal aspect; $\times \frac{1}{2}$. Fig. 3. *Porcellanaster caeruleus*, Thoms.; abactinal aspect; nat. size. Fig. 4. *Psolus ephippifer*, Thoms.; showing plates of dorsal marsupium; $\times 3$.





I



2

OPHIUROIDEA.

FIG. 1. *Ophiomitra chelys* (Thoms.); dorsal aspect of the disc; $\times 4$.

FIG. 2. *Ophiomusium pulchellum*, Thoms; oral aspect of the disc; $\times 7$.





Holothurians are derived from two sources. Those that have comparatively recently migrated from shallower waters, even to depths of 2,900 fathoms, and that, like the *Cucumaria*, still resemble their littoral ancestors, are few both in species and individuals. The great majority are Elasipoda, which must have originated long ago from a type very different to the present shallow-water fauna. From the three Elasipoda previously known, and all from the N. Atlantic and the Arctic Sea, the "Challenger" raised the number to fifty-two species, divided into nineteen genera, which were nearly all found at depths greater than 1,000 fathoms, and had a universal distribution, some species ranging almost from pole to pole. The answer to the question how our knowledge of the Holothurians was increased by the "Challenger," will, therefore, largely consist of a summary of elasipodan peculiarities.

The differentiation of an upper and lower surface, producing a bilateral symmetry, which may be seen in some of the ordinary *Dendrochirota* and *Aspidochirota*, is in the Elasipoda carried to a strange extreme, and is accompanied by an unusual symmetry in the arrangement of the pedicels and processes (Fig. 7). The ambulacral



Fig. 7.—*Peniagone wyvillei*, Théel; 2,425 fms.; nat. size.

appendages of the under surface alone are intended for locomotion, these being particularly large in the typical Elasipoda, and arranged in a single row on each side of the body, forming distinct pairs of legs. They tend to appear in fixed places and in a fixed number, often a small one, in every species of the more typical Elasipoda. They usually lack a terminal plate, sometimes even a sucking disc; but they are stumpy and often have a firm external skeleton. They are probably used, not as the tube-feet of other echinoderms, but as the limbs of more highly organised animals, to move and to dig in the soft bottom-ooze. The appendages of the upper surfaces also tend to be fixed in position and definite in number; and their large nerve-supply indicates that they serve as organs of touch. The tentacles form a disc around the mouth, and as the animals move along the bottom of the ocean, help to fill the alimentary canal with the ooze, from which such nutriment as it contains is extracted. There is no trace of respiratory trees. Auditory organs, in the shape of small sacs

containing otoliths, are often abundantly developed, but there are no eyes. The preceding characters appear to be those in which the Elaspoda have been modified for an abyssal existence, and they show that this family has had no connection with the others, at all events with the Synaptidæ, Molpadidæ or Dendrochirota, since a remote period.

The following characters appear to have been transmitted without change from their primitive ancestors. The calcareous deposits, both in the perisome and in the spicular ring surrounding the gullet, singularly resemble those of larval forms. The water-vascular system, as in the larvæ only of other holothurians, but as in the adults of other classes of Echinoderma, is often in persistent communication with the exterior, and that, too, not only by one pore, but sometimes by a number of pores closely crowded together so as to form a kind of external madreporic tubercle.

Despite the archaic and distinctive characters of the Elaspoda, one of their families, the Psychropotidæ, closely resembles some of the Aspidochirota, such as *Stichopus*, and especially *Palopatides*—a genus first found by the "Challenger"; and this suggests that Aspidochirota and Elaspoda sprang from a common branch. Thus confirmation is lent to the view that the ancestors of the Holothurians were pedate, with an open stone-canal and a well-developed ambulacral system.

Considering the habitat of the Elaspoda, it can hardly be supposed that they undergo development with metamorphosis through a free larval stage. That direct development is possible, was shown by the interesting observations made during the "Challenger" Expedition on the development of some shallow-water Holothurians, viz., *Cladodactyla crocea*, from Stanley Harbour, and *Psolus ephippifer*, from Heard Island. In the females of the former the young were closely packed and adhering to the dorsal pedicels, while in the latter Pl. x., Fig. 4) the embryos were developed in a kind of marsupium formed by the plates of the upper surface. There is little doubt that the eggs are impregnated in the ovary, and that the free larval stage is omitted.

HJALMAR THÉEL.

ANNELIDA AND NEMERTEA.

The collection of **Annelida** made by the "Challenger" was by far the largest hitherto brought together as regards both individuals and species, no less than 330 different forms having been procured, and the majority, viz., about 220, were new to science. In comparison, the collection made by the American ship "Blake" contained only 102, and the extensive Philippine series of Semper about 160. Though no new family had to be constituted, yet in every one new species, and in many new genera, occur—some of them of a remarkable character. Further, this fine collection showed that the general

classification adopted by Malmgren, the main features of which had been tested by anatomical inquiry, was fairly satisfactory, though the genera may require reduction. No links connecting the Annelida to other groups were found, so that the present boundaries remain. Into all the novelties it is impossible to enter, but such striking facts as the sexual differences of certain Polynoidæ, the curious modification that takes place in the ventral division of the foot in others—reducing the ventral bristles to one, and the further addition to our knowledge of commensal forms, are worthy of mention. Our knowledge of the visual organs of the Annelida was extended in a noteworthy manner, especially by the discovery of large complex eyes in the Phyllodocidæ, such a condition having hitherto been known only in the Alciopidæ. Ramose types of marine annelids, again, were unknown till the "Challenger" dredged a hexactinellid sponge off the Philippines containing a complexly-branched *Syllis*, an animal, indeed, which had a furor for budding and extending into all the ramifications of the canal-system of the sponge. A single example thus takes the place of a colony, and the reproductive elements are useful chiefly for spreading the species on fresh sites. Remarkable members of the Chloræmidæ from the abysses of the Atlantic and Pacific, *e.g.*, *Trophonia wyvillei* and *Buskiella*, show that closely allied forms range from tide-marks to great depths. The tubes of many of the sedentary forms were no less striking than the animals themselves—for the beauty and ingenuity of their formation.

The Expedition showed that some species were cosmopolitan. A large number occurred in the North Atlantic, and did not range to other areas, yet this may be due to the more or less unexplored condition of these areas. Thus the Amphinomidæ (with a single exception) are absent from the north-east part of the area, while they abound in the south-western; while the Euprosynidæ appear between tide-marks in the southern parts, but are limited to the deeper water in the northern. The centres for specimens in the South Atlantic were Brazil and the Cape, and the peculiar types belonged chiefly to the Polynoidæ and Terebellidæ, the latter especially abounding in the mud of Kerguelen in the South-Indian area. The Australian region had for the most part unique types, comparatively few of which ranged into other areas. The Philippine or Japanese region was specially rich in novelties. The Expedition, further, emphasised the fact that in the warmer areas the Amphinomidæ, the Eunicidæ and the Alciopidæ were specially abundant, and that the distribution of most of the families was world-wide, *e.g.*, the Aphroditidæ of which one genus, *Latmonice*, occurs in the deeps of the great oceans and ranges also to the British Isles.

The greater number of species appear to frequent shallow water (probably because this had been most effectively worked), yet annelids are found in the deepest dredgings, such as 2,500 and 3,125

fathoms. Moreover, the genera which occur there are well known; and for this reason it is probable that further exploration will enlarge the area of the new genera. Those procured from the profound abysses are mainly tube-dwellers, and thus are more or less protected, though at the same time this fact renders their presence in the trawl or dredge more frequent. The consideration of the annelidan inhabitants of the abysses of the Pacific and the Atlantic, affords no countenance to the view that primitive types have been gradually pressed by the more prolific and hardier shallow-water forms deeper and deeper into the ocean.

Again, the food of these deep-sea forms demonstrates that many of the lower organisms, such as Foraminifera, Radiolaria, and Infusoria dwell at the bottom, and are devoured in the living condition, a fact which at once disposes of the view that nourishment is absent there. The deepest abysses of the ocean are inhabited by Annelida, and thus, food for fishes especially is to be found. Moreover, in regard to development, the same series of phenomena appear to occur in the benthal types as in those of shallow water, and in those frequenting tropical oceans as well as those amidst the polar ice.

In the *Nemertea* collected by the "Challenger," which I had glanced at before handing over to my distinguished friend, Professor Hubrecht, it was found that no change was required to be made in the classification adopted by the reporter (Professor Hubrecht), which, after all, by the aid of new terms, only rings changes on that founded on anatomical features, and clearly set forth in the work for the Ray Society in 1873. The latter classification remains as satisfactory now as formerly, though, it is true, its quiet terms do not appeal to theory. Amongst the striking discoveries in this group—made by the lamented Moseley—is *Pelagonemertes* (Pl. xii., Fig. 1), a pelagic form, figured as a mollusc by former travellers, which falls under the sub-order Anopla and the family Amphiporidæ, even its branched alimentary canal being similar to that of *Nemertes gracilis*. Two important new genera were also discovered, viz., *Carinina* and *Eupolia*, the latter placed under a special family. This valuable collection enabled Professor Hubrecht to enrich his report by an elaborate anatomical appendix, in which the additions to our knowledge were incorporated with the leading features already ascertained.

W. C. McINTOSH.

ARTHROPODA.

In the zoology of the "Challenger" the reports on *Crustacea* occupy between a fourth and a fifth part of the text, and more than a fourth part of the 2,536 plates by which that text is illustrated. They describe nearly a thousand new species, besides throwing a fresh light upon a multitude of old ones. That carcinology should have claimed so predominating a share in the "Challenger" record is, for more

than one reason, remarkable. No one of the naturalists accompanying the expedition was a specialist in this subject. It is not one which excites any very general interest in this country. Its importance in the field of faunistic discovery was, perhaps, little foreseen. The extent of the collected material embraced within its province was not readily to be appreciated by any but those who had been engaged in collecting it. One ambitious and eminent worker volunteered to describe the whole, unweeding, that in many years of toil and moil, not without storm and stress, he should scarcely accomplish his allotted part. In truth, it was not wholly unreasonable to suppose that the Crustacea of the Expedition would, collectively, form a manageable group in the hands of a veteran expert. For, primarily, the voyage was made with the object of exploring the depths of the sea, whereas crustaceans are more at home in the shallows. Writing on the Ostracoda, Dr. Brady says, "The work of the 'Challenger' gave us no collections whatever from between tide-marks, nor from the laminarian zone, and these two zones usually swarm with microscopic life." Similarly, of another group, Dr. Hoek says, "As the exploration of the coasts of islands and continents was of secondary importance during the cruise of H.M.S. 'Challenger,' we need not wonder that the Cirripedia of these regions are badly represented in the collections made during the voyage. Only occasionally were specimens collected in the neighbourhood of the coasts." The Stomatopoda, as Professor Brooks observes, are restricted to shallow waters, or to waters comparatively shallow. Of the Anomura, Dr. Henderson remarks, that in the collection a few of the shallow-water groups are but poorly represented, "while many well-known and widely-distributed species are conspicuous by their absence." Above all, perhaps, it might be said of the Isopoda and Amphipoda, that they were out of the direct line of investigation, since so many of them frequent the land and fresh-water streams and lakes, burrow in the sand and mud of the shore, hide away in seaweed, under stones, in the crannies of rocks and rock-pools, in estuaries, in inconsiderable depths of the open sea, or in the narrow strips of shore rarely uncovered at the lowest ebb of a spring-tide. Yet, in both these groups, our knowledge has been wonderfully enriched by the "Challenger" collections.

Only at Kerguelen do the conditions of research seem to have been made decidedly favourable to the gathering of Crustacea, and the results obtained from that melancholy island were really surprising. For here, in a stay of twenty days, were found three new species of Schizopoda, five of Cumacea, seventeen of Isopoda, thirty-seven of Amphipoda, four of Copepoda, and nineteen of Ostracoda. Sixteen new genera were required for these accessions to the fauna of Kerguelen. Heard Island, not far off, yielded several other new forms of interest. But in spite of the large and unexpected acquisitions from these sullen regions, there is reason to believe that their crustacean fauna is still very imperfectly known. Not all the species

observed were brought home. Not all that were brought home have yet been determined. Not all the localities most likely to be productive were searched with thoroughness or searched at all. Judging, then, from the general results of the "Challenger" explorations, and from the special result at one spot where the conditions of investigation were exceptionally favourable, it may be inferred that the new forms discovered, though so numerous, were few in comparison with those awaiting discovery. The inference is supported by the great number of species of Crustacea which have been brought to light by subsequent researches, in some cases avowedly or evidently instigated by the successes, or the equally suggestive failures, of the "Challenger" work.

In regard to the distribution, horizontal and bathymetrical, of Crustacea, not only were a large number of facts ascertained, but the problems demanding solution were brought into prominence, so that subsequent expeditions have known both what points needed special attention, and how they needed to be approached.

In regard to the Brachyura, Miers believes the depth of 1,875 fathoms, at which *Ethusa* (*Ethusina*) *challengeri* was taken, to be the greatest that had been recorded for any species of crab, and points out the coincidence that this genus, which supplies the deepest living species of the Brachyura, is also that of which the species "evinced the greatest degree of degradation from the Brachyuran type." According to Dr. Henderson, any knowledge of the bathymetrical distribution of the Anomura was almost entirely wanting until furnished by the "Challenger." His *Tylaspis anomala* (Pl. xiii., Fig. 1) was taken at a depth of 2,375 fathoms. His genus *Latreillopsis* is an important link between *Homola* and *Latreillia*, corroborating the view that those genera, at one time widely separated, and very different in general appearance, ought to stand in the same family. About 2,000 specimens of *Macrura* were examined by Spence Bate, including many strange larval forms, as well as many fine and many remarkable adult species. Some members of this series came from below 3,000 fathoms. The next group was claimed by Spence Bate as belonging to the *Macrura*. It was, however, separately reported on by Professor G. O. Sars, who writes:—"The collection of Schizopoda procured during the long voyage of H.M.S. "Challenger" has turned out extremely rich and of very special interest, containing, as it does, several most remarkable new types, the examination of which has led to a much fuller comprehension of the morphology of the Schizopoda and their relation to other crustacea than was previously possessed. The various collections, having been made in widely-distant tracts of the ocean, an important contribution to the geographical distribution of species has likewise been acquired." Of the Squillidæ, though the number of adult specimens was small, the collection, according to Professor Brooks, "throws light upon many interesting problems, and furnishes

the material for a more exhaustive and satisfactory discussion of the phylogenetic relationships and the natural classification of the various genera and species than has been possible hitherto." Further he remarks that "the collection of pelagic Stomatopod larvæ is very rich, and it has yielded the material for tracing the history of several of the larval types, and also for establishing, in every genus except one, the connection between the adults and their larval types." Of the Cumacea only fifteen species were obtained, but fourteen of them were new. Members of this group can descend to a depth of 2,000 fathoms. At a like depth were found nine species belonging to seven distinct genera of Isopoda. In the Amphipoda the wide range of the Hyperidæ was decisively made patent, these being especially pelagic animals, most of them probably passing a great part of their time at or near the surface, while those which descend to great depths seem capable of coming at least occasionally to the top of the water. Among the Gammaridæ, also, there are some wide-ranging species, since some are common, for example, to Kerguelen and Great Britain; but, however cosmopolitan some forms may be, every new locality explored seems to reveal some gammarids of its own. The "Challenger" collection of Amphipoda has helped to show that, notwithstanding the many striking differences among them (Pl. xii., Figs. 3, 4), they are at present an order as clearly and sharply defined as any in the animal kingdom. All the known species in zoology are either decidedly amphipods or decidedly not amphipods. Time and space, however, are not so poor but what the intermediate forms, alive or dead, may yet be discovered. In contrast to the Amphipoda, which at present are practically unknown to geology, the Phyllocarida have long been limited to palæozoic fossils, with the small exception of the living *Nebalia bipes*. But the "Challenger" Expedition tripled the extant contents of the group by adding two new species and two new genera. Metschnikoff considered *Nebalia* to be a "phyllopodiform decapod," but Sars, after a detailed consideration of the forms at his command, believes that its relationship to other crustaceans will be more correctly expressed by calling it "a copepodiform branchiopod." As for the Copepoda, Dr. John Murray says that they were rarely, if ever, absent from the tow-net gatherings when examined on board ship. That all these gatherings did not come into Dr. Brady's hands is easy to explain. As every collector knows, the most ardent desire for storing specimens is sometimes quenched by the prolific abundance, the obtrusive superabundance, of aquatic life. Little account is made of Crustacea by landmen because they are so seldom in view. Insects are rare in the ocean. But what insects are on land, that crustaceans are at sea—sometimes remorselessly plentiful.

THOMAS R. R. STEBBING.

The above general summary of the results in Crustacea pays regard to the fact that we have been favoured with special notes by

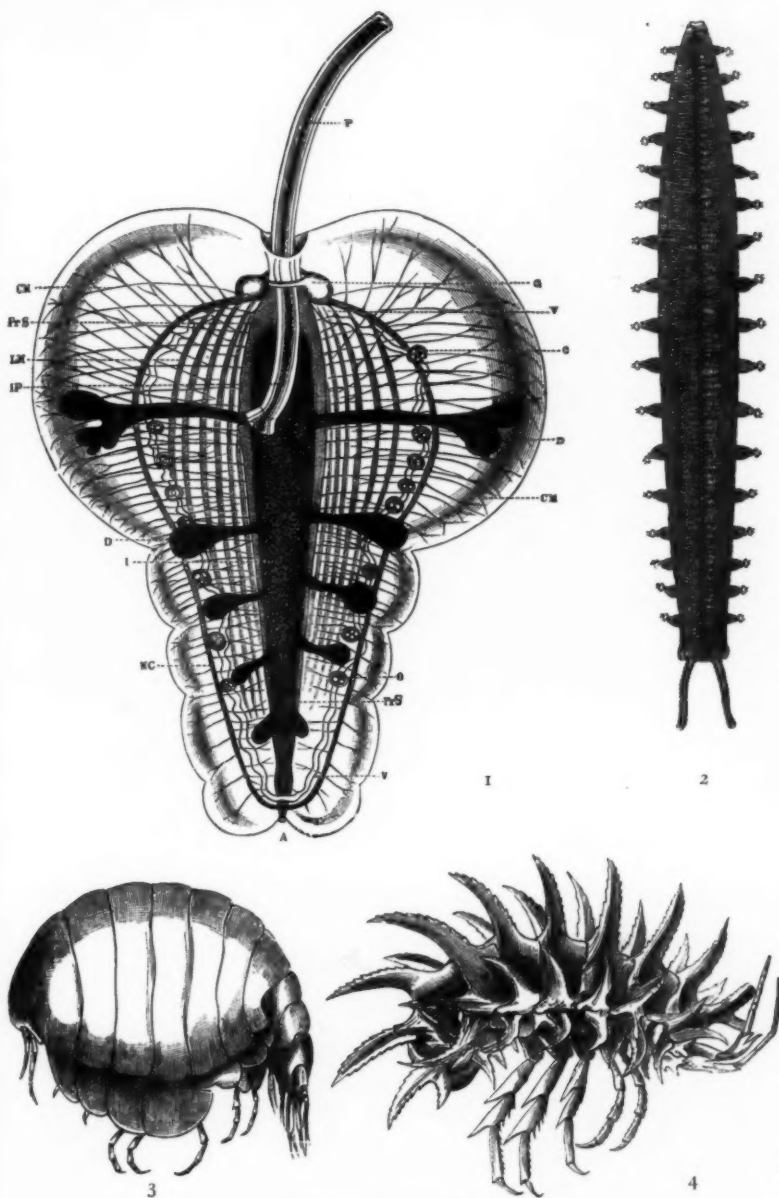
the authors of the Reports on Isopoda and Cirripedia, as well as a short account of the Ostracoda by our veteran authority on that group.

In the number of new species and genera, the "Challenger" collection of *Isopoda* excels any yet formed. In certain genera, notably *Arcturus* and *Serolis*, the number of species collected double the existing lists. In the Asellidæ a great number of new shallow-water species were collected round the shores of Kerguelen, while the deep sea yielded numerous interesting forms.

Apart from additions to our faunal lists, the chief facts of interest derived from the study of the "Challenger" Isopoda, concern the modifications induced by life at great depths in the ocean. Many deep-sea animals are totally blind; yet many species found in the deepest hollows of the ocean, appear to have perfectly normal eyes. These discrepancies were partly accounted for by the theory of abyssal light. The histological study of the eyes of certain deep-sea Isopoda, particularly of *Serolis* and *Arcturus*, shows, however, that the appearance of well-developed eyes was often deceptive. Anyone, before having recourse to the microtome, would assert that the deep-sea *Serolis neera* was as keen-eyed as any species of the genus. Yet sections through the eye show that it is in a condition of degeneration; apart from the faceted cornea there is but little of recognisable eye-structure left. In *S. bromleyana* the eyes are well marked but entirely devoid of pigment; no trace of optic tissue could be found by microscopical investigation. It seems, therefore, as if the external and less important portions of the optic organs were the last to go. Several species of *Arcturus* indicate similar degradation in the eyes; in some the crystalline lens had increased in size, become opaque and lost its clear-cut outline. It appears, therefore, that to explain the occasional persistence of well-developed eyes in this group, there is no need of any theory of abyssal light; it is more likely that the state of preservation of the eyes is an index of the length of time that the species in question has been an inhabitant of the deeper waters. The "Challenger" material also enabled me to describe a new type of eye, confined to the Serolidæ, and to the closely allied Cymothoidæ, and recently found in other species of *Serolis* by Watase.

Modifications due to the scarcity of oxygen at great depths were found in two remarkable new types. In all Isopoda (except certain parasitic forms) the last pair of abdominal appendages are swimming feet, not modified for breathing as are the pairs in front; but in *Anuropus*, a genus of Cymothoidæ, these appendages also entirely resemble the branchial abdominal appendages which lie in front of them. In *Munnopsis pellucida* the skin, instead of being thick and strongly calcified, as is the case with all other Isopoda, is thin and transparent; this, I imagine, would facilitate the absorption of greater quantities of oxygen from the water.

In the deep-sea forms of Isopoda as of other Crustacea, spines are often richly developed. In *Serolis bromleyana* (Pl. xiii., Fig. 2), *S. neera* and

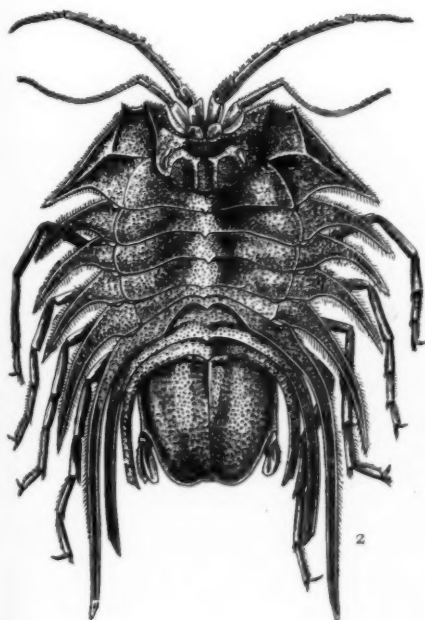
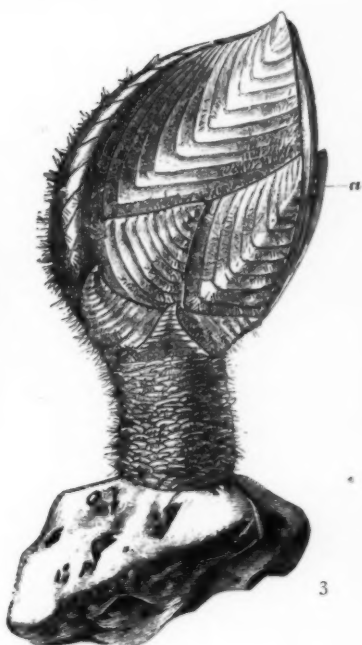
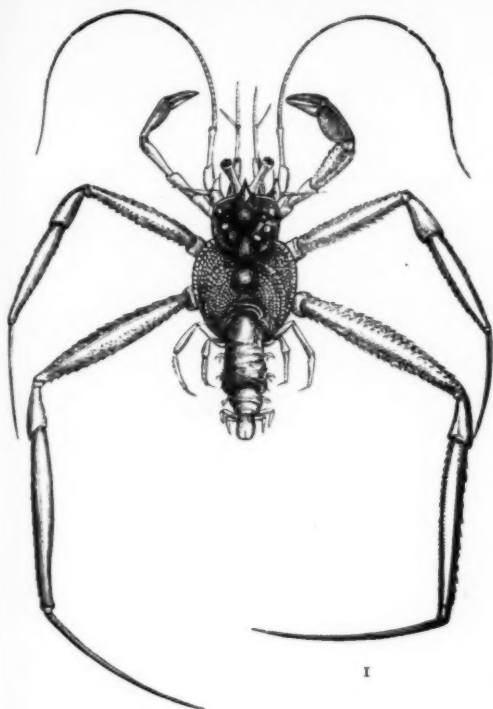


WORMS AND ARTHROPODS.

FIG. 1. *Pelagonemertes rollestoni*, Moseley; from dorsal surface; enlarged. P, proboscis, partly extended. I, intestine with diverticula (D). G, superior nerve ganglion. V, vascular trunk. O, ovaries. CM, circular muscles. LM, longitudinal muscles. FIG. 2. *Peripatus capensis*, from the dorsal surface. FIG. 3. *Andania gigantea*, Stebbing; an amphipod; nat. size. FIG. 4. *Acanthozona carinata*, Stebbing; an amphipod; enlarged.



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ARTHROPODS.

Fig. 1. *Tylaspis anomala*, Henderson; a Pagurid; S. Pacific, 2,375 fms.
 Fig 2. *Serolis bromleyana*, Suhm; an Isopod; Antarctic, 1,975 fms. Fig. 3.
Scalpellum regium, Hoek; a stalked Cirripede, with complemental male (a).
 Fig. 4. *Megalasma striatum*, Hoek; a stalked Cirripede; off the Philippines.





S. gracilis, the epimera are pulled out into long spines; but this is not the case in the fourth deep-sea *Serolis*, *S. antarctica*. It is, however, in the genus *Arcturus* that this peculiarity is most apparent. *A. glacialis* is almost dangerous to handle from the multitude and sharpness of the spines which deck its body; and other species possess almost equally effective *chevaux-de-frise*.

F. E. BEDDARD.

The definition of the generic and specific characters in the group of small Crustacea known as **Ostracoda**, is very important to naturalists, and the "Challenger" Report by so experienced a biologist as Dr. G. S. Brady is, therefore, a most valuable production. The material discussed in this Report is arranged as follows:—The Podocopa are represented by the Cypridæ, of which forty-six species placed in eight genera, two of them new, are described; the Darwinulidæ; and the Cytheridæ, which include one hundred and forty-nine species placed in thirteen genera: the Myodocopa are represented by the Cypridinidæ, including seven species in four genera, of which one is new; and a single genus of the Conchoeciadæ, comprising three species: the Cladocopa furnish only a single genus of Polycopidæ, represented by three species: the Platycopa number thirteen species of Cytherellidæ, all placed in one genus. Altogether two hundred and twenty-one species, of which one hundred and forty-four are new, are discussed.

Excepting, of course, the Myodocopa, Ostracoda were found to be living in very limited numbers, both as to species and individuals, at the greatest depths. Below 1,500 fathoms only seventeen species were recognised in thirteen dredgings; and below 50 fathoms, fifty-two species in twenty-three dredgings. Shallow waters, however, proved exceedingly prolific. The geographical, as well as bathymetrical distribution, and the biological history are fully dealt with in this valuable monograph, which has made one more leaf in the vast book of Nature fairly legible and useful for the advancement of knowledge.

T. RUPERT JONES.

The **Cirripedia** of the "Challenger" Expedition formed an extremely interesting collection of about eighty species, of which three-fourths proved new to science. Before then, the existence of Cirripedia in the great depths of the ocean was almost unknown, the species of *Scalpellum* dredged by the "Vöringen," and described by Professor G. O. Sars, being the only recorded instances. Sars met with six species of *Scalpellum* in the North Atlantic; more than forty species of this genus were collected during the cruise of H.M.S. "Challenger"; with one exception they were all new, and contained the largest forms of pedunculated Cirripedia observed up to that time. Equally interesting forms of Cirripedia inhabiting the deep sea are the representatives of the genus *Verruca*—sessile Cirripedia

characterised by their unsymmetrical shape, by the "extraordinary unequal development of the two sides of the shell," as Darwin has called it. Six new species of *Verruca* were added to the four previously known. The shape of the deep-sea species of *Verruca* is very curious, and I found it rather difficult to resist the temptation of introducing a new genus in the system for their reception. *Scalpellum* (Pl. xiii., Fig. 3) and *Verruca* are the only genera of Cirripedia observed at depths greater than 1,000 fathoms. *Dichelaspis* ranges down to 1,000 fathoms; the "Challenger" took a new species of this genus at this depth, the depth at which the other species of this genus were taken being unknown. The genus *Balanus*, of which forty-five species are known, occurs from the shore down to 516 fathoms; one of the five new species of this genus collected by the "Challenger" was taken at that depth; another—the beautiful *Balanus corolliformis*—was found to inhabit a depth of 150 fathoms, the other four lived at less considerable depths. *Alepas* and *Poecilasma* have each of them a new species in the "Challenger" collection, living at 410 fathoms, and none of the other known genera of Cirripedia (twenty-eight of the thirty-four enumerated in 1883) was ever observed at a depth greater than 150 fathoms. In all, thirteen genera of Cirripedia are represented in the "Challenger" collections, and most of them by highly characteristic forms. For one of them, *Megalasma striatum*, the creation of a new genus was necessary (Pl. xiii., Fig. 4). It is nearly related to *Poecilasma*, but easily distinguished by the form of the scutum and the width of the carina. Of floating forms of Cirripedia a dozen different species were represented in the "Challenger" collections; most of them were well-known forms, but one of them was a new species of *Chthamalus* taken from the screw of H.M.S. "Challenger," and so really deserving the name of "*Chthamalus challenger*."

A supplementary report dealt with certain points in the anatomy of the Cirripedia. The curious complemental males of the Cirripedia, the segmental organs, the cement apparatus, Darwin's "true ovaria," the eye of *Lepas*, and the female genital apparatus were treated separately, as so many *capita selecta* of the morphology of these very peculiar forms of animal life.

P. P. C. HOEK.

The grotesque and superficially spider-like creatures included under *Pycnogonida* form, perhaps, one of the most compact and homogeneous groups in the animal kingdom. Their true systematic position, however, has never been accurately determined; and although some embryological evidence has lately been adduced in favour of a possible but certainly remote connection between them and the Arachnida, the difficulties in the way of establishing the exact homology between the seven well-developed cephalothoracic appendages of a pycnogon and the six of a spider or scorpion are so grave, that the only course open to us is to follow Dr. Hoek in regarding the

group as equivalent to the Arachnida or Crustacea, but perfectly distinct from both.

Unfortunately, no light was thrown upon the origin and affinities of the Pycnogonida by Dr. Hoek's researches in connection with the species obtained by the "Challenger." But in other respects considerable additions to our knowledge were made. Representatives of thirty-six species, belonging to nine genera, were collected, and of these thirty-three species and three genera had to be described as new. Moreover, a striking fact connected with the bathymetrical range of the genera was discovered, namely, that, with one exception, the genera dredged in deep water were represented also by littoral forms. In a few cases, indeed, specimens of the same species were obtained at very varying depths. For instance, *Nymphon grossipes* at 83 and 540 fathoms, *Colossendeis leptorhynchus* at 400 and 1,600 fathoms, and *Pallenopsis patagonica* at 45 and 175 fathoms. The genus *Oorhynchus* (Pl. xiv., Fig. 1) is the only one that has no representative in shallow water. Lastly, it was observed that the conditions of life in the deep sea have by no means had a dwarfing effect upon these animals. On the contrary, many of the deep-water species attain a size which is never equalled by those near the coast. The largest species procured was *Colossendeis gigas*, a specimen of which spanned nearly 2 feet from toe to toe.

Tracheata and Malacopoda.—Since marine biological research was the main object of the cruise of the "Challenger," and collecting excursions on land rarely possible for the naturalists on board, it is easy to understand why the scientific descriptions of the strictly terrestrial forms of life find no place among the formidable array of volumes in which the researches upon the pelagic species are so elaborately set forth. Seeing, nevertheless, that many of the localities visited are islands, isolated and out of the beat of the ordinary run of vessels, and for this reason rarely, if ever, explored by collectors, it is not surprising that many of the species obtained proved to be of considerable zoological importance.

From a morphological point of view, there is no doubt that the most valuable of all the land Arthropods was the genus *Peripatus*, which Professor Moseley came across on the slopes of Table Mountain. The existence of this curious animal, half annelid, half centipede, had been known for many years; but its true position in the animal kingdom had remained up to that time an unsolved problem. The dissection, however, of freshly-killed specimens of the Cape species and a study of some of the stages of its development, enabled this able zoologist to point out once and for all, by means of the discovery of the tracheal nature of its respiratory organs and the appendicular character of its jaws, that it must take rank as the most primitive of Tracheate Arthropoda.

Very interesting, too, was the collection of Centipedes and Millipedes, which, though small in numbers, was relatively rich in

rare forms, no fewer than twenty-one species out of the forty-six that were obtained, being previously undescribed. Special mention may be made of the new species of millipede of the genus *Acanthiulus*, a genus previously only known from a single specimen in the Paris Museum, and one which in the spine-armature of its somites calls to mind some of the extinct Carboniferous members of the group. Touching the Myriopod fauna of Bermuda, an interesting point was revealed. This island lies within a stone's throw, so to speak, of the south-eastern coast of North America, and its plants, land-shells, and insects are known to be almost wholly Antillean or Nearctic in their affinities. But while forty per cent. of the Myriopoda are Antillean, none are certainly Nearctic, but there is, on the contrary, a strong and unmistakable infusion from the Mediterranean area of forms which occur also in the Azores and Madeira.

Of the Hexapoda, several new species of Butterflies, including some interesting cases of mimicry, and of flies, beetles, etc., have been described.

R. I. Pocock.

Pelagic Hemiptera.—Several beetles, flies, and other insects are found on the surface of rock-pools, or under stones between tide-marks. One genus of bugs (*Halobates*) alone among insects, is truly oceanic in habit. The small extent of the field enabled Dr. F. Buchanan White to transcribe all the previous literature on the subject, and to supplement the "Challenger" material by a study of numerous museum specimens. He described eleven species, gave a thorough account of the external structure of the insects, and recorded all known of their habits, development, and distribution.

The species of *Halobates* are small, the largest known being only 6 mm. long (Pl. xiv., Fig. 2). They are entirely wingless, and the abdomen is extremely reduced in size relatively to the thorax, the second and third pairs of legs being inserted close together, near the hinder end of the insect. These limbs are very long and slender, the tibial and tarsal joints of the second pair being provided with a long fringe of hairs. The front legs are shorter and stronger and furnished with claws, by means of which the insect anchors itself to floating substances, which provide it with rest and food. Numbers of *Halobates* may be observed in tropical seas, in calm weather, skimming over the surface of the water; they are to be met with near the shore, and also hundreds of miles from land.

Dr. White regarded *Halobates* as a very archaic type of insect, believing it never to have possessed wings, and to be near the common ancestor, from which it and its freshwater relations (*Gerris*, the Pond-skater, etc.) have descended. This view is, however, controverted by Dr. E. Witleczil, who has since studied the *Halobates* collected by the "Vettor Pisani" Expedition. He described two additional Italian species (*Wien. Ent. Zeit.*, 1886, pp. 178, 231), and, being able to make

microscopic sections of some of the insects, published a short description (*Zool. Anz.*, x., 1877, p. 336) of their internal anatomy. Finding organs normally belonging to the abdomen situated in the thorax, and modifications for an aquatic life carried to the most extreme point, he naturally regards *Halobates* as a most aberrant type of bug.

Dr. F. Dahl has recently described "Die Halobatiden der Plankton Expedition" (*Ergebnisse der . . . Plankton Expedition der Humboldt-Stiftung*, ii. g., 1893), from the N. Atlantic, separating one specimen as the type of a new species. Other species of *Halobates* have been described by Mr. F. Skuse (*Rec. Austral. Mus.*, i., 1891, p. 174), Dr. E. Bergroth (*Revue d'Ent.*, xii., 1893, p. 204), and the writer of this note (*Sci. Proc. R. Dubl. Soc.*, vii., 1892, p. 144).

Observations on the habits of *Halobates* have been lately published (*Ent. Monthly Mag.*, 2, iv., 1893, pp. 227, 252) by Mr. J. J. Walker, R.N. He notes that while the insects remain on the surface during calm weather, or in a swell without wind, they disappear "with the ripple caused by the slightest breeze." Observing also, that specimens kept in a vessel of sea-water dive on the approach of a foreign body, and swim readily beneath the surface, he concludes that it is their habit to dive into still water whenever the surface is disturbed.

In the "Challenger" Report, Dr. White transferred several insects of doubtfully pelagic habit, referred by older authors to *Halobates*, to a new genus *Halobatodes*. Dr. F. Meinert (*Ent. Meddelelser*, i., 1887, p. 140) regards these as individuals of the freshwater genus *Metrocoris*, Mayr, in which the wings have not been developed. Mr. Walker found these insects in harbours and estuaries. They are of considerable interest, as representing a transition between the (usually) winged, freshwater Hydrometridæ and the wingless, oceanic *Halobates*. The ocean is believed to have been the original cradle of all animal life, but its most gigantic inhabitants, the "great whales," and these small and humble insects must be regarded as modified land-animals driven back from the crowded continents to find a home in its waters.

GEO. H. CARPENTER.

MOLLUSCA.

As regards the Molluscs, the "Challenger" Expedition has made known a very large number of new marine forms, both genera and species, belonging to the different classes. But, from the point of view of pure zoology, all these forms are not of equal interest. We must, therefore, limit ourselves here to the chief of those whose study has yielded results of morphological importance or led to notable conclusions in phylogeny. From this point of view the following facts may be indicated as the most important:—

1. Among the peculiarities of organisation in abyssal molluscs, in relation to the conditions of their existence, there has been described the disappearance of the cephalic eyes in various Gastropoda (a fair

number of Streptoneura, and a Nudibranch Euthyneur, *Bathydoris*), and of the pallial eyes in the Pectinidæ, at depths exceeding 1,000 fathoms. The study of *Guivillea* has shown how the degeneration of the eyes takes place in the streptoneurous gastropods: the surface of the retina becomes extremely reduced, the pigment has entirely disappeared, and the epithelium of the eyeball has become uniform over almost all its extent.

2. The organisation of a group of Lamellibranchia, supposed to be without gills, has been elucidated. It has been recognised that their gills have been transformed into a muscular septum, whence the name Septibranchia given to these organisms (*Poromya*, *Silenia*, *Cuspidaria*=*Neera*). Respiration is effected by the internal surface of the mantle in the supra-septal chamber; the water enters therein by paired orifices pierced through the septum, and only opening from without into the chamber; the current of water is produced by the contraction of the septum.

3. The study of the Lamellibranchia has permitted the establishment of a phylogenetic classification based on the structure of the gills, and now more and more adopted. It has also put us in the way of recognising the general hermaphroditism of the Anatinacea (*Lyonsiella*, etc.), and the fact that, among the Mollusca, hermaphroditism is secondary and super-imposed on the female sex.

4. Among the Polyplacophora, the collections of the "Challenger" have given us a good acquaintance with forms that have but few pairs of gills—eight or even six—notably *Leptochiton benthus*, where all the gills are placed, with the smaller ones in front, at the sides of the anus, behind the foot, in a sort of branchial chamber. This fact, combined with others that we know, has led to the opinion that among the Amphineura, which are the most archaic molluscs, there originally existed numerous gills down the whole length of the body; then that, in certain forms, their number has diminished from front to back, only the posterior pairs persisting, and the last of all being the only one that is preserved in other molluscs (*Pleurotomariidæ*, *Fissurellidæ*, *Haliotidæ*, Lamellibranchs, and dibranchiate Cephalopods); in *Nautilus* the last two are preserved.

5. Among the surface organisms, the very numerous "Pteropods" collected have, by the facts of their organisation, enabled us to show that the class Pteropoda must disappear, and that we must, with Souleyet and Boas, place the animals so called in the Opisthobranchia. It has been possible to fix the precise position of the Gymnosomata, which come from the Aplysioidea, and to confirm that of the Thecosomata, which come from the Bulloidea. The special case of torsion recognised in the straight Thecosomata is one of the grounds for believing that the Opisthobranchs—indeed, all the Euthyneura—have undergone an untwisting, contrary to the twisting of the Streptoneura or Prosobranchia, and that they are derived from streptoneurous ancestors.

6. Among the Nudibranchia collected, a Doridian, *Bathydoris* (Pl. xiv., Fig. 3), possesses a respiratory apparatus composed of many separate "branchial" plumes. This structure, which occurs also in the Hexabranchiæ, permits us to affirm that the perianal branchia of the Doridians is formed by the union of many pallial appendages, and in no way corresponds to the ctenidial branchia of other molluscs.

7. Finally, among Cephalopoda (without trespassing on the special notice by Mr. Hoyle), the capture of a *Spirula*, one of the five complete individuals known, has been one of the most precious gains. The study of its structure has shown that this form has no relations with the "Calciophora" (*Sepia*, etc.), or with any Myopsid. *Spirula* is an Oigopsid, and among them the least removed from the parent stock of modern Dibranchiates.

PAUL PELSENER.

The "Challenger" collection of **Cephalopoda** contained seventy-two species, disposed in thirty genera, of which thirty-two species and four genera were new; it was only found necessary, however, to create one new family (Amphitretidæ). The collection is as remarkable for its deficiencies as for the types represented in it. The rare capture of pelagic forms was probably due to the enormous activity of these animals, which is so great that they can only be captured when the vessel is moving rapidly, a condition unfavourable to the use of the tow-net. A more important means of obtaining them is by the examination of the stomachs of predaceous birds, fish, and cetaceans; one of the most remarkable items in the collection, a large pen referred to *Chiroteuthis*, was taken from the stomach of a shark. Science would be greatly advanced if whalers and those engaged in the capture of sea-fowl would preserve the contents of such stomachs in spirit. It is disappointing that not even a fragment of one of the giant squids was found: the largest specimen was the type of *Cirroteuthis magna*, which is more than a metre long, and is the largest individual of the genus yet obtained. Neither were the expectations fulfilled of those who hoped that forms hitherto known only as fossils would be among the spoils. Moseley tells us that "even to the last every cuttle-fish which came up in our deep-sea net was squeezed to see if it had a Belemnite's bone in its back"; but no such precious discovery was made.

All the specimens of *Sepia*, including ten new species and some previously known only by their shells, were obtained during the cruise from the Eastern coast of Australia, through the Malay Archipelago, to Japan; a confirmation of the idea that the Indo-Pacific region is the metropolis of this genus. Great additions were also made to the already large genera *Octopus* and *Loligo*; but these were of less interest than the unique specimens made the types of new genera, each of which presents some character either entirely novel or important as furnishing connecting links between previously

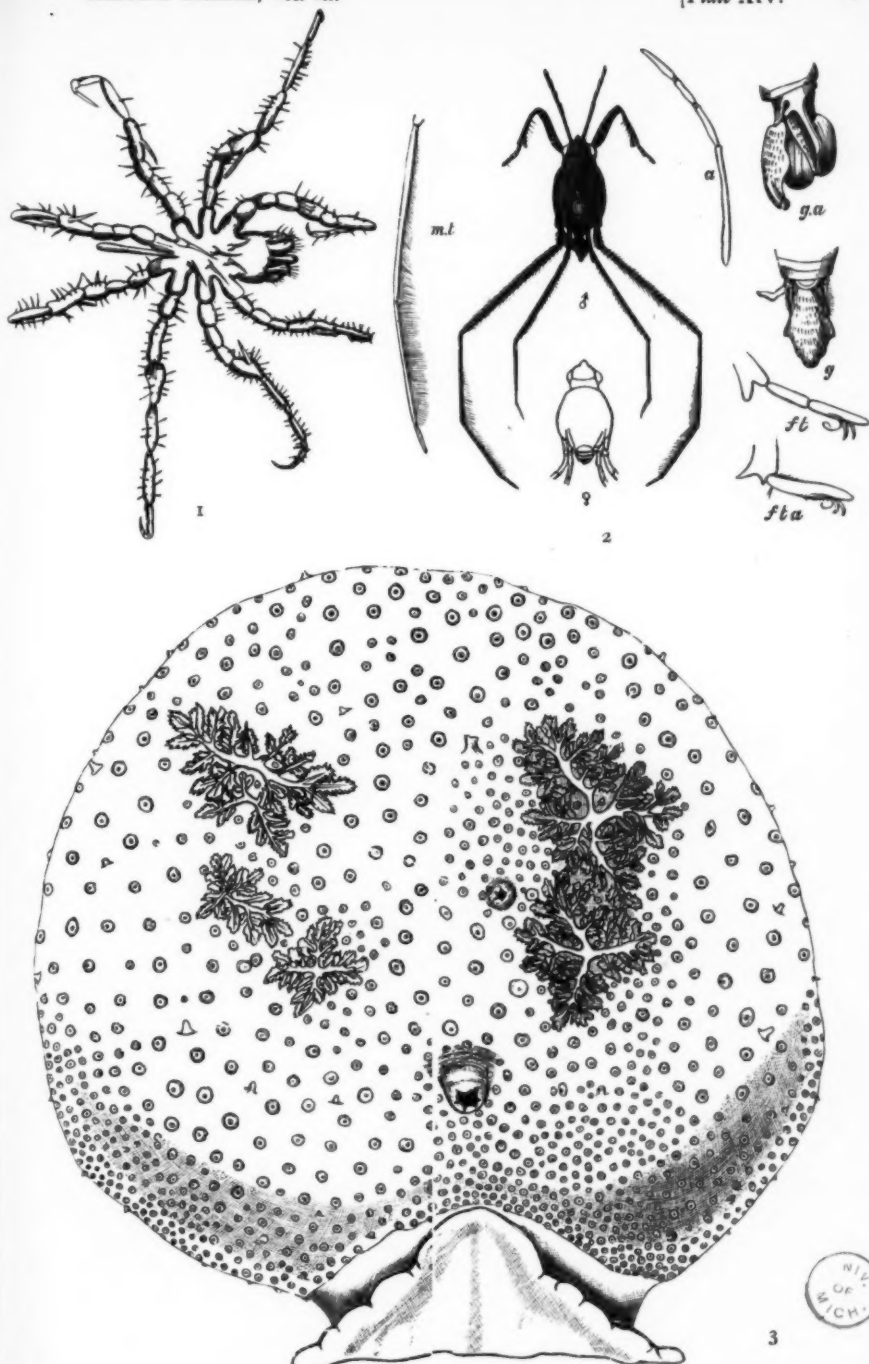
known forms. *Amphitretus* (Pl. xv., Fig. 2), for instance, differs from all other cephalopods in that the mantle is firmly united to the siphon, leaving two openings into the branchial cavity, one on either side, immediately below the eyes. *Japetella* and *Eledonella* are two curious gelatinous and semi-transparent forms, allied to *Bolitaena*. *Bathyteuthis abyssicola* (Pl. xv., Fig. 1) is one of the few cephalopods that really does appear adapted for life at great depths: the small fins are in marked contrast to those of pelagic species, while the small suckers and delicate tentacles are equally little fitted for raptorial purposes; on the other hand, the large circumoral lip seems well-suited for collecting nutritive matters from an oozy bottom. *Promachoteuthis* has a small, round body with very large fins; it comes from the N. Pacific. *Histiopsis*, from the S. Atlantic, is closely related to *Histioteuthis*, *Chivoteuthis*, and *Calliteuthis*.

As regards their distribution, the Cephalopoda seem divisible into Pelagic, Littoral, and Abyssal; and all the species of any one genus, usually belong to the same group. The occasional occurrence of a species in two categories is probably due to the want of complete information. Exact localities and conditions should be carefully noted by future collectors. Meanwhile the "Challenger" collection has confirmed the general statement, that, while pelagic animals belong to but few types, each of which has a comparatively wide area of distribution, littoral forms belong to many species, each of which is confined within narrow limits. Deep-sea forms seem to be even more widely distributed than pelagic ones, owing to the uniformity of the conditions of life, especially temperature. The bathymetrical results are unsatisfactory, as there was no means of determining at what depth the animals found in the dredge or trawl were captured.

W. E. HOYLE.

BRACHIOPODA.

These animals live chiefly on coral-reefs and shallow rocky bottoms; the deep-sea species are small in size, and few both in species and individuals; moreover, they are not easily collected by dredge or trawl. Our knowledge was, therefore, confirmed rather than added to by the "Challenger." As in other groups, abyssal forms are less localised than those that occur in seas of moderate depth. As the three most interesting species brought home by the "Challenger," Davidson who reported on them, quotes the following:—*Terebratulina wyvillei*, the largest species of the genus, dredged in 390 fathoms, off Culebra Island, north-west of St. Thomas, in the West Indies. *Terebratulina wyvillei* (Pl. xv., Fig. 3), which occurs over a wide area, at depths from 1,035 to 2,900 fathoms, the greatest depth whence any living brachiopod has been brought up; a small species, with a shell, as in all deep-sea brachiopods, smooth, glassy and semi-transparent. *Discina atlantica* (Pl. xv., Fig. 4), another of the widely spread abyssal forms; the cirri proceeding from the edges of the mantle are of great comparative length, equalling the diameter of the shell. Only a small



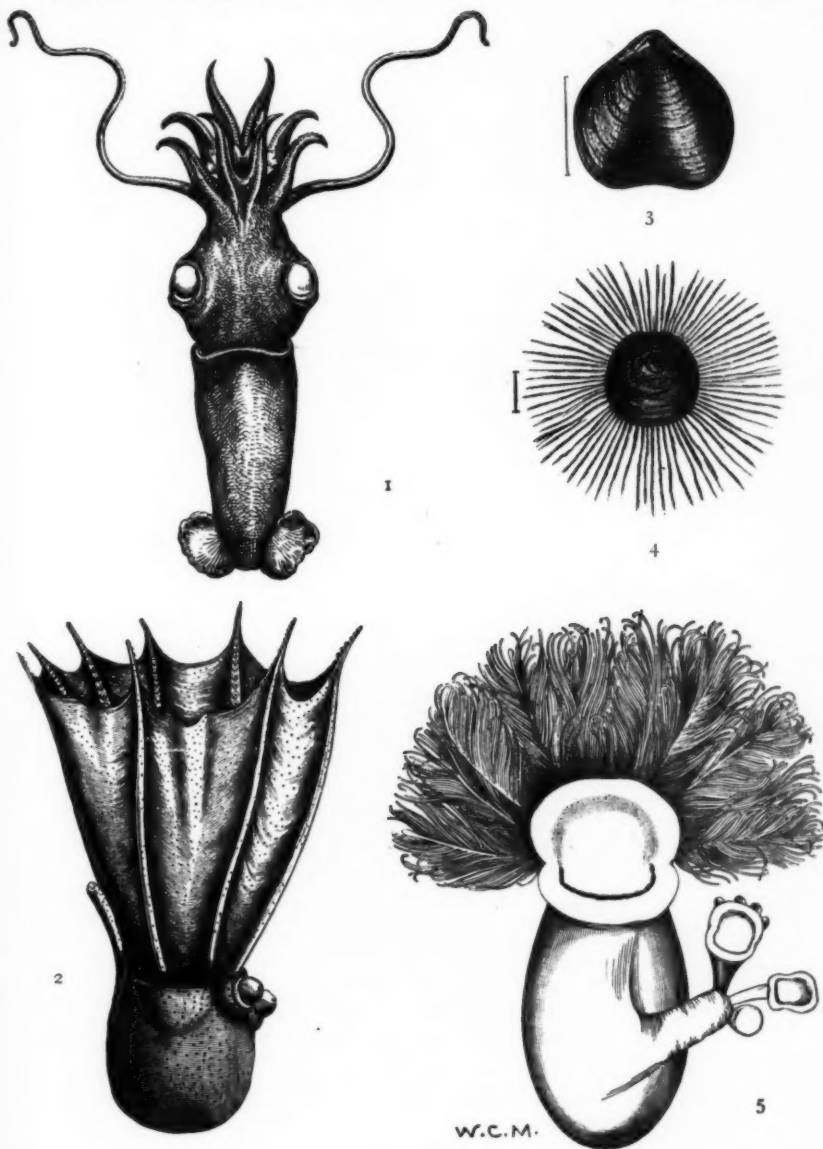
ARTHROPODS AND MOLLUSCS.

Fig. 1. *Oorhynchus aucklandia*, Hoek; α Pycnogonid; 700 fms. \times 7½.
 Fig. 2. *Halobates wüllerstorffi*, Frauentf.; pelagic hemipteron, male and female. Fig. 3. *Bathydoris abyssorum*, Bergh; showing the five branchial tufts, one probably lost from the right side; near branchiae on right is the renal pore; below, in the middle line, is the anal papilla; at the bottom is the expanded foot; nat. size.



2





CEPHALOPODS, BRACHIOPODS, CEPHALODISCUS.

Fig. 1. *Bathyteuthis abyssicola*, Hoyle; Southern Ocean, 1,600 fms.; nat. size. Fig. 2. *Amphitretus pelagicus*, Hoyle; Kermadec Is.; somewhat enlarged. Fig. 3. *Terebratula wyvillei*, Dav. Fig. 4. *Discina atlantica*, King. Fig. 5. *Cephalodiscus dodecalophus*, M'Int.; ventral view. The proboscis is seen surrounded by the tentacular arms. The mouth is concealed by the posterior half of the proboscis.





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number of the species brought home are positively known to occur in the upper Tertiaries, and none of the abyssal forms have yet been found in the fossil condition.

F. A. B.

BRYOZOA.

The reports by Messrs. Geo. Busk and A. W. Waters added largely to our knowledge of the variety of form in this group, and acquainted us with the delicate and flexible deep-sea species, though only one could be regarded as belonging to a decidedly abyssal family—the *Bifaxariadæ*. The geographical distribution of the abyssal forms bears no evident relation to the bathymetrical. Still less is light thrown on the fossil species. In fact the chief interest possessed by the Bryozoa of the "Challenger" has now been removed from them by the transference of *Cephalodiscus* to the group next considered.

HEMICHORDATA.

Cephalodiscus may fairly claim to be one of the most novel types which have been made known as the result of the voyage of the "Challenger." This extraordinary animal was dredged in the Straits of Magellan, at a depth of 245 fathoms. No special attention seems to have been paid to it on that occasion, and the first cursory examinations which were afterwards made gave no clue to its real affinities.

The animal (Pl. xv., Fig. 5) measures some 2 mm. in length, and is provided at its anterior end with six pairs of multipinnate tentacular arms. Near the other end the body is produced into a short stalk, from the tip of which buds are produced. These buds break off after reaching a certain stage of development, so that no "colony," in the ordinary zoological use of the term, is produced. The animal is, however, gregarious, and large numbers are found in the cavities of a semi-gelatinous "cœnoecium," which is the product of their joint activity. The analogy of *Rhabdopleura* suggested that the cœnoecium was in large part at least secreted by the "buccal shield" or proboscis.

Although the affinity of *Cephalodiscus* to *Rhabdopleura* was soon recognised, it was first shown in the "Challenger" Report that the former animal was unmistakably allied to *Balanoglossus*. No conclusion could have been more unexpected. The two genera are totally unlike at first sight; their internal structure is identical in all essential particulars.

The three main regions of *Balanoglossus*, the proboscis, the collar, and the body proper, are clearly marked in the immature buds (Fig. 8) of *Cephalodiscus*. The divisions of the body-cavity corresponding to these regions are distinct and separate even in the adult animal; and consist, as in *Balanoglossus*, of an unpaired proboscis-cavity (*b.c.*¹), and of paired cavities (*b.c.*², *b.c.*³) belonging to the two succeeding regions. Two of the special peculiarities of *Cephalodiscus* are the

position of the anus on the dorsal side, not far from the mouth, and the production of the collar-region into the twelve tentacular arms which have already been alluded to. The proboscis-cavity opens to

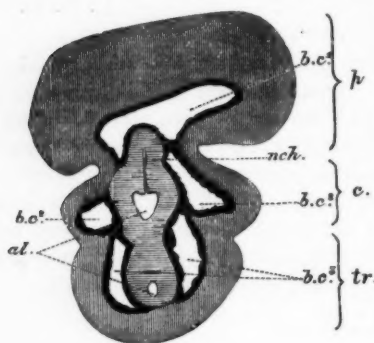


FIG. 8.—*p.* proboscis; *c.* collar; *tr.*, trunk or body; *al.*, alimentary canal.

the exterior by a pair of proboscis-pores, which perforate the nervous system. The collar-cavities communicate with the exterior by a pair of collar-pores, which are situated in the immediate neighbourhood of a pair of gill-slits. The central nervous system is situated in the dorsal region of the collar, and it is outside the basement-membrane of the epidermis. The narrow stalk of the proboscis is strengthened by a tubular notochord (*nch.*) extending forwards from the pharynx.

If the above description is really accurate, there can be little doubt with regard to the affinity of *Cephalodiscus* to *Balanoglossus*, however dissimilar the two animals may at first appear. It is important to notice that confirmation of the account published in the "Challenger" Report has appeared from more than one side.

Should *Cephalodiscus* and *Rhabdopleura* be really related to *Balanoglossus*, the presumption is that they have nothing to do with the Bryozoa, a group in which they were temporarily placed. It might have been hoped that the study of *Phoronis* afforded by the "Challenger" material would have had some bearing on this question. But in spite of the anatomical account of *P. bushi*, McIntosh, the new species described in the Report, and in spite of the more recent and fuller accounts of the anatomy of the genus, published by Benham and Cori, the affinities of *Phoronis* cannot be said to be at all clearly known. It is by no means impossible that this animal is related to *Cephalodiscus*; and some considerations suggesting an affinity between the two animals were brought forward in the "Challenger" Report. But the resemblances are too uncertain, and the differences too obvious to place the conclusion on the same level of probability with the conclusion that *Cephalodiscus* is related to *Balanoglossus*. It cannot be too strongly urged that *Cephalodiscus* and *Rhabdopleura* belong to Bateson's group of the Hemichordata, and that they have nothing to do with the Bryozoa. *Phoronis* may or may not come in the same group, but the question should not be obscured by the assumption, at present not sufficiently warranted, that it necessarily has affinities in the direction of the Bryozoa.

S. F. HARMER.

THE TUNICATA.

The large collection of Tunicata made during the Expedition has added greatly to our knowledge of this group, as regards both its morphology and its distribution. The pelagic tunicates (Salpidæ, Doliolidæ, and Pyrosomidæ), which form an important constituent of the surface fauna of the ocean, have, on account of their abundance and the comparative ease with which they may be obtained, attracted the attention of naturalists and voyagers in many parts of the world. Hence the "Challenger" collection of these forms contains comparatively few novelties; but it is of considerable value, since, from the constancy and care with which tow-net observations were conducted, and their results preserved, it affords much additional information as to the distribution of these pelagic Tunicates horizontally, and to a less degree vertically. One noteworthy form is the new species *Pyrosoma spinosum*, of which a magnificent specimen, over four feet in length, was obtained in the North Atlantic, but was unfortunately not preserved entire. The remarkable new genus, *Octacnemus*, described first by Moseley, of which two species are known, seems to be an abyssal and considerably modified ally of the pelagic Salpidæ. A new family, the Octacnemidæ, has been formed for its reception.

The collection is rich in *Ascidie Compositæ*, but although many of them are new species, the great majority belong to well-known genera. This can be accounted for by the fact clearly brought out by the "Challenger" collection, that the *Ascidie Compositæ* form essentially a shallow-water group, the bulk of the collection having been obtained close to land, or at localities, such as Kerguelen Island and Port Jackson, where the shore fauna was investigated. A few Compound Ascidians were, however, obtained from great depths, such as 1,600, 2,050, and 2,900 fathoms, but they show few notable morphological peculiarities. Perhaps the form most worthy of special mention is *Pharyngodictyon mirabile*, in which the branchial sac is in the curious simplified condition found in *Culeolus* amongst Simple Ascidians. The horizontal distribution of the group is very wide, representatives being found in all the great oceans and in almost all latitudes.

Among the *Ascidie Simplicies*, the most important new forms constitute a small group of pedunculated Cynthiidæ, apparently confined to deep water, and characterised by several striking peculiarities. They are more nearly allied to *Boltenia* than to any other previously known genus, and have been placed in two closely related new genera *Culeolus* and *Fungulus*, the former containing seven species and the latter one. Their most important morphological feature is the very remarkable condition of the branchial sac, which is simplified, apparently, by the total absence of the system of fine interstigmatic vessels; the result being that the large meshes formed by the intersection of the transverse vessels, and the longitudinal bars,

are not divided up into stigmata, as they are in the case of a typical Simple Ascidian. This peculiar condition of the branchial sac seems to be associated with the abyssal zone, as it has apparently been evolved independently in at least four different groups of deep-sea ascidians, viz., *Culeolus*, *Fungulus*, *Bathyoncus*, and *Pharyngodictyon*, while it has not been found in any forms from shallow water.

In *Culeolus* the branchial sac is strengthened by the development in the vessel-walls of a system of gracefully branched and curved calcareous spicules, marked internally by a series of "contour" lines. These are quite different in appearance from the fusiform echinated spicules found in some species of *Cynthia*.

Another noteworthy feature in the anatomy of the genus *Culeolus*, is the condition of the blood-vessels of the test in some of the species. In *C. murrayi* the terminal twigs of the vessels open into large vesicles placed just below the surface of the test, and only separated from the external medium by a very delicate membrane. In several of the species there are thin-walled hollow papillæ or projections from the surface of the test, and these are in free communication with either the large vesicles or the ends of the vessels. This is obviously an accessory respiratory apparatus, permitting the blood circulating in the test (which when the heart contracts dorso-ventrally is impure) to be brought into such close relations with the external water as to ensure a certain amount of oxidation.

A large number of other new species of *Cynthiidæ* were obtained, but the only others which cannot be referred to a known genus are *Bathyoncus mirabilis*, *B. discoideus*, and *B. minutus*, forms which agree with the typical *Styelinae* in having simple tentacles, but differ from them in having a branchial sac of the skeleton type found in *Culeolus* and *Fungulus*. *Styela* is remarkable on account of its very extended bathymetrical range. Most of the species are found in shallow water, some few between tide-marks; while six species in the collection are from between 100 and 600 fathoms, and two, *S. bythia* and *S. squamosa*, both fairly typical members of the genus, were obtained at a depth of 2,600 fathoms. (Pl. xvi., Fig. 2.)

In the *Molgulidæ*, two gigantic pedunculated forms, destitute both of hair-like processes from the test and incrusting sand, have been placed in a new genus, *Ascopera*. In the *Ascidiidæ* there are three noteworthy new genera—*Corynascidia*, *Abyssascidia*, and *Hypobythius*, all from deep water. *Corynascidia suhmi* is, like so many other of the abyssal forms, supported upon a peduncle. The position and course of the intestine are peculiar, and the branchial sac is one of the most beautiful and delicate known. *Abyssascidia* is a connecting link between the well-known British genera *Ascidia* and *Corella*. It resembles *Corella* in the position and course of the intestine, while, in the structure of the branchial sac, it exhibits the simpler arrangement found in *Ascidia*, from which again it differs in the condition of the dorsal lamina, and in the large number of lobes surrounding the

branchial and atrial apertures. A little group of three species, for which the new genus *Ecteinascidia* has been founded, forms a connecting link between the previously known Clavellinidæ and the Ascidiidæ, and shows that the group of Social Ascidiæ, established in 1828 by Milne Edwards, must now be merged in the Ascidiæ Simplices.

The geographical distribution of the Simple Ascidiæ is very wide; but it appears from the "Challenger" investigations that they are not specially abundant in the northern hemisphere, and are comparatively scarce in tropical latitudes, while they attain their greatest numerical development in southern temperate regions. The bathymetrical range is also wide, extending from the littoral zone down to 2,900 fathoms; still they are mainly a shallow-water group, and are found in greatest abundance immediately around the coast in a few fathoms of water.

Altogether the "Challenger" collection of Tunicata contained 184 new species (in addition to a number of marked varieties), and these have required the formation of twenty-one new genera, and three new families—the Cœlocormidæ, the Polystyelidæ, and the Octacnemidæ. Among the theoretical conclusions that have been deduced from their study are:—

1. That the Tunicata are to be regarded as a degenerate offshoot from the Protochordata, with some primitive Clavellinid as the ancestral form of the fixed Ascidiæ.
2. That *Pyrosoma*, although now a pelagic free-swimming organism, was derived from the fixed Compound Ascidiæ.
3. That Ascidiæ Compositæ are an unnatural or polyphyletic group, having probably been derived from the ancestral Simple Ascidiæ at three distinct points—the result being that the Compound Ascidiæ form three groups: (1) the Polystyelidæ; (2) the Botryllidæ; and (3) the remainder, which are more nearly related to particular groups of Simple Ascidiæ than they are to one another.

W. A. HERDMAN.

VERTEBRATA.

Fishes.—The great contribution to Ichthyology made by the "Challenger" Expedition, was the provision of a broad and sure foundation of our knowledge of the abyssal fish-fauna. In the introduction to his volume on the "Deep-sea Fishes," Dr. Albert Günther has already clearly stated the extent of this contribution and summarised previous knowledge of the subject, so that it is unnecessary to do more than quote from his observations. Risso, in 1826, was the first to distinguish an abyssal fish-fauna, and he not only assigned to it certain species, but also attempted to state the depths at which they habitually live. Between 1843 and 1860 the Rev. R. F. Lowe's researches among the fishes of the ocean round Madeira added the further important fact that some fishes live during their earliest stages at or near the surface, while they retire into comparatively great depths in the course of their growth. He also determined the precise

depths at which certain species occur. Between 1862 and 1866 Mr. J. Y. Johnson continued Lowe's investigations, though not clearly perceiving the significance of the many deep-sea fishes he discovered. During the decade following 1860, Dr. Günther himself also discussed the bearing of these discoveries, with what is now proved to have been much foresight; and by 1870 the time had arrived for some definite and systematic attempt to solve the various problems that had arisen. The voyage of the "Challenger" was precisely opportune, and the naturalists in charge obtained no less than 610 specimens, all carefully localised, and many with an approximate record of the depth at which they were captured. It then became clear that the deep-sea fishes had a very wide distribution, and some were definitely proved to live at no less great a depth than 2,750 fathoms. Ample material was also furnished for an examination of the so-called "eye-spots" on these remarkable animals (Pl. xvi., Fig. 4); and the researches of Moseley and von Lendenfeld (forming a supplement to Dr. Günther's report) gave the first adequate idea of the structure of these organs. It is now certain that they produce light, and at least the more specialised of them appear to be directly under the control of the will of the fish. The most interesting general result of the "Challenger" work, however, was the proof that all the deep-sea fishes are modifications of forms still inhabiting the shallower waters. *Bathypterois*, for instance (Pl. xvi., Fig. 3), is a new Scopeloid genus which has retained much of the outward appearance of surface fishes, and might be thought equally well organised for life in some quiet dark water near to the surface. The chief modification is in the pectoral rays, which are much elongated, some of the upper ones being separated from the remainder of the fin. They are evidently organs of touch, enabling the fish to examine objects hidden in the ooze, which its imperfect eyes could not detect. The Palæontologist might have expected to find among the deep-sea fishes a few refugees from an older fauna; but none of them represent types earlier than those of the Cretaceous period. The few very antique fishes that remain have taken refuge in the fresh waters, or become adapted to the present conditions of the shore and open ocean.

The only report on **Reptiles** is a short memoir on the development of the Green Turtle, contributed by the late Dr. W. K. Parker to the first volume in 1880. This is based on a collection of embryos brought from Ascension by the Expedition, and on other specimens subsequently collected in the same place by Dr. Maclean, R.N. It is illustrated by no less than thirteen plates, and gives the first detailed account of the development of the skull in the Turtles. Some of the more striking embryos themselves are also briefly described, and Dr. Parker particularly emphasises the fact that they exhibit many more body-segments, especially in the neck and tail, than might be expected from the number of vertebræ in the adult.

A. SMITH WOODWARD.

Considering that the principal function of the "Challenger" was to collect deep-sea creatures, the collection of **Birds** formed by the Expedition was highly creditable, especially to Mr. John Murray, who interested himself in the matter. The result was that 900 specimens were collected, and several new species were obtained. To work out these collections Dr. Sclater, who was entrusted with their description, called to his aid several well-known ornithological experts, such as Count Salvadori, the late Marquis of Tweeddale, Dr. Otto Frinsch, Mr. Osbert Salvin, and Mr. Howard Saunders.

The two most important collections were those made in the Philippine Islands, when several new species were discovered, and in the Admiralty Islands, which was untrodden ground to the naturalist, and here the bulk of the species procured were new to science. The other memoirs deal with more well-worn subjects, as all the localities visited by the "Challenger" had been, more or less, explored by previous naturalists and collectors, and no novelties were to be expected; but the thorough way in which Mr. Murray procured specimens of birds on every possible occasion resulted in the addition of an extremely fine series of Penguins and other sea-birds to the British Museum. The portion of vol. ii. devoted to the birds embraces an important series of memoirs, amounting to 180 pages, and is illustrated by thirty coloured plates by Smitt.

The two most important memoirs are, of course, those by the late W. A. Forbes, on the Petrels (Tubinares), and Dr. Morrison Watson on the Penguins (Spheniscidæ). The former of these reports is published in the fourth volume of the series, and the latter in the seventh. Both of these memoirs are of the highest importance to science, and have had a marked influence on the classification of the orders of which they treat. They are, moreover, excellently arranged as regards material and tabulation of results, and, though Dr. Watson's is the larger of the two reports, they are both very complete. If nothing besides these two contributions to the history of the Class Aves had been published in the "Challenger" Report, Mr. John Murray would have earned the gratitude of ornithologists for all time for the interest he displayed in collecting such a rich store of material.

R. BOWDLER SHARPE.

Of the **Mammalia**, whether from land or sea, no great collections were obtained by the "Challenger." She was not fitted as a whaler, and the cetacean specimens obtained were mostly in the form of skulls and bones. The marine mammals could have yielded no richer results than were obtained by the accomplished anatomist, Sir William Turner, who has kindly sent us the following note:—

In the memoir on the **Cetacea** collected during the voyage, the skeleton of a young specimen of Layard's Whale, *Mesoplodon layardi*, from the Falkland Islands, is described for the first time, and is

compared with the skull of an adult collected at the Cape of Good Hope. The minute structure of the teeth, both in the young and adult cranium, is specially examined and compared with that of the teeth in Sowerby's Whale. It is proved that, in the earlier stages of growth of the teeth in these Cetacea, the structure does not differ materially from the ordinary human or carnivorous tooth, the crown being invested by enamel, the fang by cement, whilst the great body of the tooth consists of dentine, in the core of which is a pulp-cavity. The exceptional character of the erupted teeth in the adult is due to the disappearance of the enamel from the crown, the cessation in the development of the dentine, the excessive formation of osteo-dentine, modified vaso-dentine and cement, through which the pulp-cavity becomes almost obliterated, and the fang assumes dimensions, which, in Layard's Whale, lead to the growth of the very remarkable strap-like tooth so characteristic of this cetacean.

The memoir also contains an account of a skull of a *Ziphius cavirostris* (Cuvier's Whale), from New Zealand, which is compared with a similar skull from the Shetland Islands. The author considers them to be of the same species, and regards the geographical distribution of Cuvier's Whale as equal to that possessed by the Sperm Whale.

In another chapter, the cetacean bones dredged from the floor of the ocean are described. These consisted mainly of the tympanic and petrous bones, more or less encrusted with manganese. They were all found south of the equator, and to a large extent belonged to the genus *Mesoplodon*, of the Ziphioid group of whales, though a few could not be referred to existing species. They were associated with large numbers of sharks' teeth, belonging to the genera *Lamna*, *Oxyrhina*, *Carcharodon*, but the species, so far as we know are extinct. Many of the specimens were dredged from a depth of from 2,000 to 3,000 fathoms (Pl. iii., Fig. 3, and Pl. xvi., Fig. 1).

The memoir on the **Seals** collected by the "Challenger" contains a description of the external characters and skeleton of the Elephant Seal, *Macrorhinus leoninus*, from Kerguelen Island; of the skeleton of Weddell's Seal, *Leptonychotes weddelli*, from Kerguelen, a comparison of the skull of a young and adult Lion Seal, *Otaria jubata*, and an account of the skeletons of Fur Seals collected on Kerguelen Island and in the Messier Channel off the west coast of South America. These latter specimens are referred to the genus *Arctocephalus*, sp. *gazella, australis*.

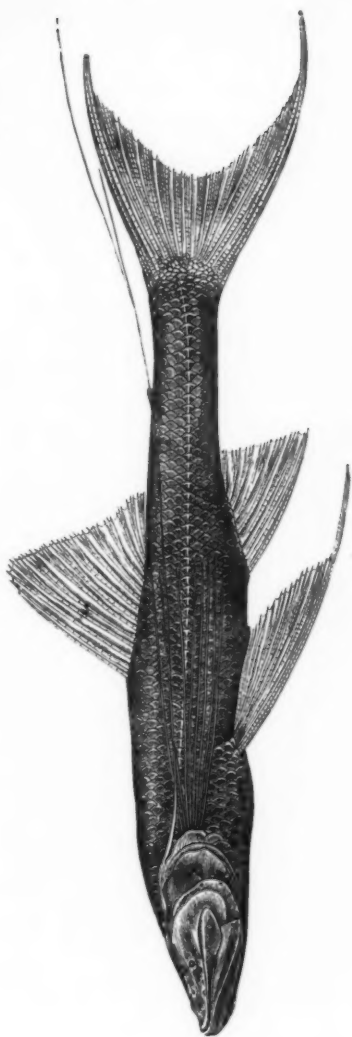
In another chapter the known species of seals and the walrus are classified according to their anatomical characters, based principally on a study of the skull. The distinguishing cranial characters of each species are believed to be worked out with more precision than in previous attempts at the classification of this interesting group of marine mammals. The author does not consider that there is sufficient anatomical evidence to warrant the division of the genus



1



2



3



4

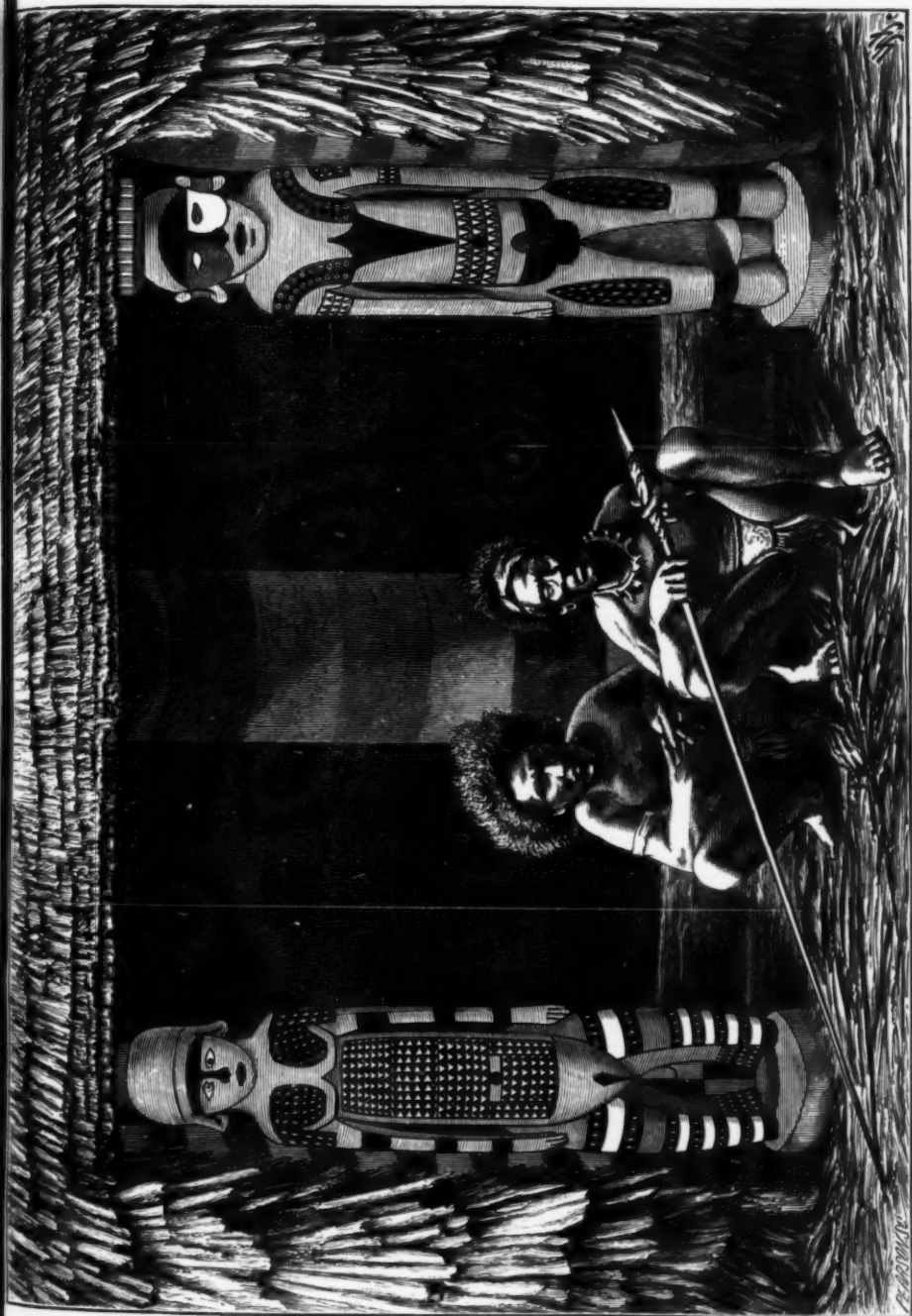
Fig. 1. Manganese nodule containing ear-bone of *Mesophodon*.

Fig. 2. Manganese nodule with two tunicates (*Styela squamosa* and *Styela bythia*) and a brachiopod attached Southern Indian Ocean, 2,600 fms.

Fig. 3. *Bathypterois longipes*, Günth.

Fig. 4. *Echiosstoma micripnus*, Günth.; 2,150 fms.





ENTRANCE TO A CLUB-HOUSE, WITH CARVED AND PAINTED DOOR-POSTS,
Wild Island, Admiralty Islands.

From a sketch by Dr. J. J. Wild, Artist to the "Challenger" Expedition.





Trichecus (walrus) into an Atlantic species differing from that frequenting the North Pacific Ocean, as has been proposed by Mr. J. A. Allen.

Another chapter describes the brain of the walrus and of the elephant seal, and compares the arrangement of the convolutions and fissures of the cerebrum with those present in the brains of carnivora, apes, and man. It concludes by giving, in a tabular form, the fissures and convolutions in the brain of a dog, which apparently have homologous arrangements in the ape's brain.

The memoir on the seals concludes with an appendix, containing a detailed description by Dr. W. C. Strettell Miller, of the myology of several species of seals from the author's collection. So far as the specimens permitted, the nerves which supply the muscles were dissected and described.

WILLIAM TURNER.

The collecting of **Land Mammals** had, as a matter of course, little place in the official programme of the voyage of the "Challenger"; but, nevertheless, when any specimens were by accident obtained, they were preserved, and, by the end of the cruise, amounted to about sixty in number.

Some few of these, such as a *Thylacine*, *Armadillo*, *Platypus*, were handed over to Professor D. J. Cunningham for dissection, and resulted in his valuable paper on "Some Points in the Anatomy of the *Thylacine*, *Cuscus*, and *Phascogale*," in vol. v., while the majority were sent direct to the British Museum, where they now are.

The value of these specimens lies not in their novelty or rarity (for being mostly obtained near seaport towns, and more or less by accident, without systematic trapping, they are almost wholly well-known species), but in the accurate particulars as to their localities and dates which accompany them. Thanks to these particulars, bats from Hawaii, shrews from Manilla, moles from Japan, and mice from Chili, all have their value to the specialist working at the several groups, even if not of sufficient importance to demand a general account of the collection.

It is hoped that another time, whether on a great expedition like that of the "Challenger," or during ordinary surveying voyages, a few traps, large and small, may be set out systematically whenever and wherever possible, for the results are sure to be of value sooner or later. Few but specialists are aware how incredibly ignorant we are of the exact distribution of mammals, not so much of the great groups, but of the species, while much of this knowledge will by degrees become more and more impossible to obtain, owing to the rapid spread over the earth's surface of Europeans, pigs, dogs, rabbits, rats, etc.

The visit of such a ship as the "Challenger" to all sorts of out-of-the-way islands, would, therefore, be an opportunity for gaining information about distribution, habits, etc., which could never be obtained by the ordinary mammal collector, who has to ignore known

species and get enough rarities or novelties to make his trip pay commercially, and, therefore, would never think of visiting islands where a few known species would alone be found.

OLDFIELD THOMAS.

VI.—ANTHROPOLOGY.

WHEN one takes into consideration the length of the cruise and the interesting places visited by the "Challenger," regret can only be felt that more Anthropological work was not accomplished. Apart from the efforts of the late H. N. Moseley and R. von Willemoes-Suhm, it does not appear that anyone was interested in this science. A great opportunity, as is usual in our official expeditions, was almost neglected. Even the photographs were as a whole unsatisfactory. The general instructions were, however, wide enough, as the following extracts will show:—

"Every opportunity should be taken of obtaining photographs of native races to one scale; and of making such observations as are practicable with regard to their physical characteristics, language, habits, implements and antiquities. It would be advisable that specimens of hair of unmixed races should in all cases be obtained." And again, the "special interest" of the ethnology of New Britain and New Ireland was pointed out; but the "Challenger" did not go to either place, and spent only six days at the Admiralty Islands.

A small collection of skulls and bones was obtained, which in the able hands of Professor Sir William Turner has yielded interesting results; but this is due not so much to the material collected, valuable though it was, as to the fact that Sir William has made use of other data. Of the 153 crania of which measurements are given, only sixty-four were "Challenger" specimens. These consisted of the Bush Race (2), Fuegian and Patagonian (5), Australian (3), Admiralty Islands (13), Sandwich Islands (33), Chatham Island (4), and New Zealand (4). In addition, reference is made to the investigations of other craniologists, so that each collection of skulls forms an excuse for a little monograph of that particular people. Very few bones of the skeleton were collected; but by utilising that important series of human skeletons in the Museum of the University of Edinburgh, Sir William has written a very valuable essay on comparative osteology. These two Reports practically constitute the only text-book in the English language on these subjects, but it is necessarily extremely fragmentary. It will be seen that, with the exception of the Bush and Fuegian crania, all the specimens came from Oceania, and the "Comparison of the Crania of the Pacific Islands" is a masterly summary of the ethnology of that region of the globe. Even in some of the remote island groups there is a diversity in the cranial characters. "These variations can be sufficiently accounted for on the theory that two distinct races, a dolichocephalic Papuan [Melanesian] and a brachycephalic Maori

[Polynesian], are in some islands pure, in others mingled with each other, either in distinct colonies living side by side in the same island, or by intermarriage; though on the western side of the Pacific region the brachycephalic Malay and Negrito have without doubt exercised an influence in modifying the cranial and other characters of some of the islanders in that region." But Sir William thinks that "there are certain residual quantities of which it is not possible to give a satisfactory explanation, on the supposition that these are the only races which have ever occupied these islands." He refers more especially to the remarkable megalithic monuments in several of the islands.

Professor Turner writes, "there is sufficient information to enable me to say that racial differences are not confined to the skull, but occur also in other parts of the skeleton." He does not find "that any one race dominates, in all its characters, over all other races; or that any one race, in all its characters, is lower than all other races. There does not seem to be a graded arrangement, such as would lead one to say that the white races, which we will assume to be the most highly developed, have been derived, by successive stages of slow and gradual perfecting of structure, from the lowest existing black race, or, indeed, from any one of the existing black races."

In his charming book "Notes by a Naturalist on the Challenger," Professor Moseley gives numerous original anthropological observations, many of these are of great interest, and they indicate a keen eye and an appreciation of the points of real importance. There is, for example, a suggestive little essay on the metamorphosis of Hawaiian gods into hook-like ornaments, and the chapter on the Admiralty Islands is of especial value; but Moseley has given a more detailed and admirable account of "The Inhabitants of the Admiralty Islands, etc.," in the *Journ. Anth. Inst.*, vi., 1877, p. 379. The skulls collected on the occasion of this visit were the first that have been described. A considerable part of Moseley's book is reprinted in First and Second Parts of vol. i. of the "Narrative of the Cruise," prepared by Dr. J. Murray. In these books there is some additional ethnographical information, which is illustrated by a few coloured plates, photographs, and woodcuts. Here, again, the section dealing with the Admiralty Islands is the most complete and the best illustrated (see Pl. xvii.); it is, in some respects, supplementary to Moseley's account.

A. C. HADDON

SOME NEW BOOKS.

PROFESSOR PRESTWICH ON SOME GEOLOGICAL PROBLEMS.

COLLECTED PAPERS ON SOME CONTROVERTED QUESTIONS OF GEOLOGY. By Joseph Prestwich, D.C.L., F.R.S., etc. 8vo. Pp. xi.-279, with 13 plates and 8 figures. Macmillan & Co. 1895. Price 10s. net.

As Professor Prestwich is the acknowledged *doyen* of British geology, his opinions are entitled to the most respectful consideration. He always brings to any discussion a judgment resulting from an unusually long experience, and his writings have always shown that he is especially apt at preparing judicial statements of the arguments on both sides of the vexed questions of geology. One, therefore, turns to the volume expecting important help in defining and limiting the issues of current geological controversy. It is, therefore, rather a disappointment to find that the book consists of reprints. But as the articles have been revised and sometimes enlarged, a series of plates added, and the papers collected from scattered sources, the volume must be heartily welcomed, both as conveying fresh information and giving some of Professor Prestwich's latest conclusions in a convenient form.

The book contains six articles. These deal with "Uniformitarianism," "The Date and Duration of the Ice Age," "Plateau Man in Kent," "The Agency of Water in Volcanic Eruptions," "The Thickness of the Earth's Crust," and "The Rate of Rise of Underground Temperatures." The first of these is a reprint from the *Nineteenth Century*, and contains a protest against accepting the positive conclusions of physicists as to the rigidity of the earth, or the exaggerated estimates of geologists as to the length of time required for certain geological operations. Professor Prestwich strongly objects to what he calls "the *Fetich* of uniformity"; he states the views of some of the most devoted worshippers, as if they were those of the orthodox members of this school. He quotes Croll, and accepts him apparently as a typical representative of the Uniformitarians, although his theories have long since fallen from the prominent position which they once held. With Professor Prestwich's criticisms upon these views we heartily agree, though without in any way losing faith in the uniformity of geological phenomena. Professor Prestwich fully admits that the forces of erosion and the modes of sedimentation are "the same in kind as they have ever been; but we can never admit that they have always been the same in degree" (p. 14). With this probably every uniformitarian would agree: differences in degree must have happened; rainfalls vary, climates alter, and ocean currents gain or lose in erosive power by simple changes such as we can see going on around us at present. No one can set a limit to these changes; they appear to us to vitiate every attempt to calculate geological time in terms of years. And we are sorry to have to confess that, when Professor

Prestwich tells us that "there is every reason to believe . . . that Palæolithic Man and his companions came down to within some 10,000 to 12,000 years of our times" (p. 11), we regard his estimate as quite as unphilosophical as those, seven times as long, against which he argues. The second article attempts to estimate the date and duration of the Glacial Period; it seems open to the same objection, that the data are too inexact to repay the labour of using. The third article appears to us the most important in the volume, as it contains more new matter than the others, and is illustrated by a series of good plates. It describes the evidence for the supposed existence of man on the chalk plateaux of Kent in times earlier than the Palæolithic, and coincident or earlier than the gravels known as the "Southern drift." The implements are of a very primitive character, and many competent authorities have declined to accept them as of human workmanship. The specimens figured on the plates, however, seem convincing. There are, however, with these some of the normal Palæolithic implements, such as a spear head of the St. Acheul type (pl. xi., Fig. 38); and how the two series came into association, Professor Prestwich admits to be still uncertain.

The fourth article discusses the various theories that have been put forward to account for the water given off in volcanic eruptions. Professor Prestwich maintains that the old theory, that volcanic action is one of the results of contraction of the earth during cooling, is in fullest agreement with the facts, and further, that the steam given off is formed from water which works its way down from the surface, and is not occluded by the rocks of the interior. The article on the "Thickness and Mobility of the Earth's Crust" is that which is most likely to arouse energetic dissent, especially from its conclusion that volcanic action is incompatible with a thick crust. The final article discusses at length the data by which the rate of increase of underground temperatures can be determined. The numerous probable sources of error are described, and many of the most familiar measurements are dismissed for failure to allow for these. Professor Prestwich rejects a large number of records, and from those which he accepts he calculates the mean rate of increase of temperature as 1 degree Fahr. for every 48 feet.

J. W. G.

IN our review of the four-handed text-book on Botany recently issued by Gustav Fischer, we asked how it was possible to issue so admirable and so copiously illustrated a work at so small a cost. The publisher writes to inform us that the cost of publication is not appreciably less in Germany than in England, less still has Bonn University anything to do with the matter. The explanation, he says, is due to the great pleasure he has had in bringing out as cheaply as possible a book which the four Bonn professors and teachers had done their best to make as valuable and original as possible.

MESSRS. DULAU & Co., who have been appointed agents for the sale and distribution of the Royal Society's publications, have issued a complete price list of those that are still to be had.

NEWS OF UNIVERSITIES, MUSEUMS, AND SOCIETIES.

THE following appointments have recently been made:—

Dr. E. Knoblauch, to be Assistant in the Botanical Institute at Tübingen University; Dr. P. Dangeard, Professor of Botany to the Faculty of Sciences at Poitiers; Dr. H. Fischer, to be Assistant in the Botanical Institute at Heidelberg University; Dr. F. Saccardo, to be Assistant in the Botanical Division of the Royal "Weinbauschule" at Avellino; Dr. Günther, Ritter Beck von Mannagetta, to be Extraordinary Professor of Systematic Botany at Vienna University; Dr. F. Schütt, to be Ordinary Professor of Botany at Greifswald University; Dr. Karl Futterer, to be Professor of Geology and Mineralogy at the Technical High School of Karlsruhe in Briesgau; Mr. Frank Finn, to be Deputy Superintendent of the India Museum, Calcutta, in the room of Mr. E. C. Cotes, resigned. Dr. N. V. Ussing succeeds the late Professor Johnstrup in the Chair of Mineralogy, at Copenhagen; Dr. F. Karsch, becomes Extraordinary Professor of Zoology at Berlin University. Professors E. Du Bois Reymond, K. Weierstrass, and Eduard Suess have been elected honorary members of the Royal Irish Academy; Professor W. Dames and Dr. P. Groth have been elected Foreign Correspondents of the Geological Society of London; Professor G. B. Howes succeeds Mr. W. P. Sladen as Secretary of the Linnean Society.

THE Linnean Gold Medal has been awarded to Dr. Ferdinand Cohn, the eminent botanist; the "Prix de Candolle" of the Geneva Physical and Natural History Society has been divided between Dr. O. Warburg, of Berlin, for his monograph on the Myristicaceæ, and Professor R. von Wettstein, of Prague, for his monograph on the genus *Euphrasia*. Dr. John Murray has received the honorary degree of Doctor of Science from Cambridge University, he has also been awarded the Founder's Medal by the Royal Geographical Society. Both awards are in recognition of his work in connection with the "Challenger" Expedition. The other awards of the Geographical Society have been adjudged as follows:—Patron's Medal to the Hon. George N. Curzon for his travels and publications on Persia, Northern India, and French Indo-China; Murchison grant to Eivind Astrup for his journey in Greenland with Peary; Back grant to Captain Larsen for his Antarctic researches; Gill memorial to Captain Pringle; Cuthbert Peck grant to G. F. Scott Elliot for exploration of Ruwenzori and the west of Victoria Nyanza. At Commemoration honorary D.C.L.'s were conferred by Oxford University on Sir William Flower and Professor Michael Foster.

THE Statute establishing a final honour examination in Anthropology in the Honour School of Natural Science at Oxford University was (*proh pudor!*) rejected by sixty-eight votes to sixty. During his retention of the Readership in Anthropology, Dr. E. B. Tylor may, however, solace himself with the title Professor.

CANADA is to have a National Park. The Algonquin Park, for so it is called, will be a large reservation in the province of Ontario. The *American Naturalist* states that no hunting, trapping, or destruction of animal life will be permitted within its boundaries.

THE collection of birds' skins forwarded to England recently by Dr. Donaldson Smith, as a result of his explorations in Somaliland, has now been examined and described by Dr. R. Bowdler Sharpe, who read a paper on the subject at a meeting of the Zoological Society on May 21. Dr. Sharpe considers the collection to be a most important one, and to contain no less than twenty-two species new to science. One of these, a very handsome goatsucker (*Caprimulgus donaldsoni*) was actually procured on board ship before the expedition started on its long journey to Lake Rudolph, and if the young explorer had but known that he had begun with a new species at the outset, he might have taken it as an omen of the good luck, which has undoubtedly followed his expedition. The most striking novelties were obtained by Dr. Smith on the Darro Mountains, and near Sheikh Husein and Sheikh Mohammed in Western Somaliland. The finest of these new species is a Touracou (*Touracus donaldsoni*), and a Hornbill (*Lophoceros sibbensis*), as well as two new seed-eating Finches (*Crithagra donaldsoni* and *C. maculicollis*). In the lower country and in the district of the Webi Shebeyli Dr. Smith also met with some very interesting new forms, among them three new species of Larks, and a new Bulbul (*Pycnonotus dodsoni*).

A MOST successful expedition to the Salvage Islands, Canaries, Madeira, and Porto Santo has just been accomplished by Mr. Ogilvie Grant and Mr. Cecil Baring, who were accompanied by Mr. Grönvold, the taxidermist at the British Museum. Three weeks were available for collecting purposes, nine days of which were devoted to the Salvage Islands. A large collection of bird-skins and eggs was secured, and included a fine series of the White-breasted Petrel (*Pelagodroma marina*) and the White-rumped Storm Petrel (*Thalassidroma cryptoleucura*), with many eggs of the former, and one of the latter. *Puffinus assimilis*, in all stages of growth, was collected, together with eggs, and an egg of Bulwer's Petrel was also obtained. Of Madeira birds, the chief captures included a splendid pair of *Columba trocaz*, and large series of the Robin, Goldcrest, and Chaffinch peculiar to the island. Of the other vertebrates, the most interesting forms are the peculiar Great Salvage Mouse, and a large series (seventy-two species) of fish preserved in spirit. Four hundred and fifty land and freshwater molluscs, 400 arthropods, 700 insects, and a few echinoderms and worms, besides numerous plants and a small collection of rock specimens, bear striking witness to the value of these small expeditions when conducted by competent and energetic leaders.

IN addition to the support already noted by us as promised to the International Bibliographic Bureau, we learn that the Swiss Government has now made itself financially responsible for the headquarters of the undertaking, which will be at Zurich. A thousand francs is already contributed to the preliminary expenses by French institutions. The *Zoologischer Anzeiger*, the *Anatomischer Anzeiger*, and the *Bibliographie Anatomique* are all making arrangements to co-operate with the new scheme, the success of which must now be held assured.

WE learn from Captain Marshall Hall that Professor Torquato Taramelli, of the University of Pavia, has been nominated to represent Italy on the International Commission on Glaciers.

THE BRISTOL GEOLOGISTS' ASSOCIATION has arranged excursions to Portishead (July 21), Stroud Valley (August 11), and Dundry (September 15). The National Home-Reading Union holds its summer assembly at Leamington Spa, June 29-July 8. Mr. J. E. Marr will deliver four lectures on the geology, and Mr. Scott Elliot four lectures on the botany of the district. The first conference and excursion under the Irish Field-Club Union will take place on July 11-17. The programme is briefly as follows:—July 10, evening reception by Dublin Club; July 11, proceed to Galway and inspect town and neighbourhood; July 12, excursion to the Twelve Bens, Connemara; July 13, excursion to Ballyvaughan and Burren district; July 14, being Sunday, members make their own arrangements; July 15, excursion to the Aran Islands; July 16, excursion to Oughterard and Lough Corrib.

CORRESPONDENCE.

THE TEETH OF THE HORSE.

IN the article on "The Teeth of the Horse," in the April number of this journal, it was stated, with reference to the preparations at the Natural History Museum, that the skulls were collected and presented by Mr. Goodall. It is, however, only fair to him to add that in most cases the teeth had already been exposed in the skulls, and that the skulls were not simply collected, but were carefully selected from a much larger series in his possession, with a view to showing the salient features of the dentition at each particular stage. There is, unfortunately, no indication in the paper of the amount of labour and thought which Mr. Goodall had already expended on the series; and, in justice to him, I wish to be allowed to rectify the omission.

W. G. RIDWOOD.

CHANGE OF HABIT IN WILD BIRDS.

WHEN visiting the upper parts of Natal lately I came across what appear to be two instances of recently-acquired change of habits in wild birds. The first is that the common Griffon Vulture, Aasvogel of the Dutch (*Gyps kolbii*) has, of quite late years, commenced in this district (the watershed between the Upper Movi and Bushman's rivers) to kill living animals, not confining itself to carrion. I am aware that this habit is noted from the Cape Colony; but it would appear that in the part of Natal I visited the farmers only commenced to suffer during the last six to eight years. These birds breed in the steep cliffs of Mount Erskine, an outlier of the Drakensberg range, in large numbers, and thence scour the country. Authentic cases are given in which farmers have seen the living, healthy sheep attacked and killed, generally when at some little distance from the main body of the flock. They appear, however, generally to attack ewes when with very young lambs; first killing the mother, and then the lamb or lambs. I am also informed that, in one instance at least, they have attacked a cow, and killed her; but, although probable, I would like verification for this statement. At all events, it is quite certain that below and near Mount Erskine this habit has been quite recently developed.

Last year I was in the bush in the valley of the Upper Umkomanzi river. Parrots (*Psittacus*, sp.) are common in the bush; but, until then, had not foraged in the gardens and orchards. For the first time since the place had been settled by Europeans—a matter of twenty-five years—they attacked the fruit. Their somewhat timid disposition seemed quite altered, and they flew into the orchards in large numbers. They seemed unable to carry off the fruit, which consisted principally of apples, alone, so broke the small branches below the joint, and I saw them flying off with branches in their bills with apples attached. The excitement among them seemed intense; the discovery of such an abundant and new food-supply apparently much agitating the parrot world. No doubt, in both these cases, the change of habit will be permanent, and I thought the fact of the date of change being thus known was worth recording.

Durban, Natal,

March 29, 1895.

MAURICE S. EVANS.

NOTICE.

TO CONTRIBUTORS.—All communications to be addressed to the EDITOR of NATURAL SCIENCE, at 22, ST. ANDREW STREET, HOLBORN CIRCUS, LONDON, E.C. Correspondence and notes intended for any particular month should be sent in not later than the 10th of the preceding month.

TO THE TRADE.—NATURAL SCIENCE is published on the 25th of each month; all advertisements should be in the Publisher's hands not later than the 20th.